RECEIVED
FEB 26 1916

Vol. 2, No. 3 MARCH, 1916

THE SCIENTIFIC MONTHLY

EDITED BY J. McKEEN CATTELL

CONTENTS

Plant Distribution in California. Professor DOUGLASS HOUGHTON CAMPBELL 209

Industrial Research in America. Dr. RAYMOND F. BACON . . . 226

The Present Status of the Antiquity of Man in North America. Dr. CLARK WISSLER 234

Changsha and the Chinese. DR. ALFRED REED 239

The Malthusian Doctrine and War. EDWIN W. JAMES 260

On the Representation of Large Numbers and Infinite Processes. Dr. ARNOLD EMCH 272

Energy Content of the Diet:

Proteins in Growth. RUTH WHEELER 279

The Mineral Nutrients in Practical Human Dietetics. E. B. FORBES 282

The Chemical Nature and Physiological Significance of so-called Vitamines. Professor CARL VOEGTLIN 289

Food Selection for Rational and Economic Living. Dr. C. F. LANGWORTHY 294

The Progress of Science:

The Resources and the Inventions of the United States; Ruins of the Mesa Verde National Park; A Prehistoric Sun Temple; Scientific Items 307

THE SCIENCE PRESS

LANCASTER, PA. GARRISON, N. Y.

NEW YORK: SUB-STATION 84

SINGLE NUMBER, 30 CENTS YEARLY SUBSCRIPTION, $3.00

COPYRIGHT, 1915, BY THE SCIENCE PRESS

JUST PUBLISHT

Smith's Commerce and Industry

By J. Russell Smith, Professor of Industry in the Wharton School of Finance and Commerce of the University of Pennsylvania.

554 pp. 12mo. $1.40.

The material of this commercial geography text-book is arranged by countries, but the subordinate arrangement under the United States is by industries. In discussing the industries of the United States the author follows them into other countries, thus giving an idea of their world-wide relations. In general, he has followed the plan of making comparisons between countries instead of confining the discussion to one locality at a time.

The usual plan of treating the physical geography of a country in a separate, formal statement, preliminary to the discussion of its industries is not followed in this book. On the contrary, the physical features are treated directly in connection with the industries themselves, thus bringing out the relations between them.

Half of the book is devoted to the United States. Of foreign countries, Latin America and the Orient receive unusual attention because of our future trade expansion with those countries.

World trade routes and certain generalizations, such as the laws of trade, are reserved for the last section because an understanding of them depends on a knowledge of the facts in the preceding sections. In this section, also, are certain interesting predictions in regard to the future development of industry. Among these are the utilization of the rocky hills of New England and the arid plains of the West by means of tree crops; the diversification of farming in the South by supply crops; the greater utilization, as coal and oil fail, of other sources of power, such as wind, water, tide, and even the sun; and the extraction of nitrogen from the air and phosphorus from the sea.

Many passages relating to the history of industry are interspersed in the text. A statistical appendix of twenty-four pages will be especially valuable to schools with limited reference libraries.

HENRY HOLT AND COMPANY

44 West 33rd Street
New York

623 South Wabash Avenue
Chicago

THE SCIENTIFIC MONTHLY

MARCH, 1916

PLANT DISTRIBUTION IN CALIFORNIA

By Professor DOUGLAS HOUGHTON CAMPBELL

STANFORD UNIVERSITY

CALIFORNIA is easily first among the states of the Union in the variety and interest of its flora. Indeed there are few regions in the world which surpass it in these respects, and the problems dealing with the origin and distribution of this rich flora are full of interest.

In a paper such as the present one, it is clear that only the more obvious factors controlling plant distribution can be considered. There are many important but often very obscure problems which must be passed over here. Indeed the writer feels himself quite incompetent to deal at all with many of these.

Probably the most important factor determining the character of its flora is the geographical position of California. Covering almost ten degrees of latitude, 32° 40′ to 42°, it lies well within the warm temperate zone with conditions of temperature conducive to a luxuriant vegetation. The state is peculiarly isolated, as the high mountains and deserts to the east offer an impassable barrier to plants from the Atlantic side of the continent, while to the south are the deserts of Mexico and lower California, and on the west lie the shores of the Pacific. The state thus has many of the characteristics of an oceanic island. This isolation, no doubt, accounts for the extraordinary proportion of endemic plants found in California.

Aside from latitude the great factors controlling the climate of California are four in number, viz., (1) the great oceanic and continental barometric areas; (2) the prevailing west-to-east drift of the atmosphere characteristic of temperate latitudes; (3) the proximity of the Pacific ocean; and (4) the extraordinarily varied topography of the state.[1]

The Pacific ocean, whose immense volume of water varies but little in temperature during the year, acts as a huge thermostat and gives the whole Pacific coast an extraordinarily equable climate. Along the middle California coast the water is cold, having an average tem-

[1] For details, see the very interesting account of the climate of California, "The Climatology of California," Alexander G. McAdie, Washington, Government Printing Office, 1903.

perature of 55°, so that the summer climate of the immediate coast is relatively very low. The coast region of California feels the full benefit of the proximity of the ocean during the summer, as the prevailing winds are from the ocean, and only occasionally do land winds occur. The hottest month in San Francisco has a mean temperature of only about 60 degrees, although it lies in about the same latitude as Washington, where the mean of the hottest month is nearly 20 degrees higher. On the other hand, the coldest month of the year in San Francisco is only 10 degrees less than the hottest, while in Washington the difference is more than four times as great. In very exposed places the difference may be even less marked, and practically the same temperature prevails throughout the year. The equalizing effects of the ocean are also shown in the slight differences in temperature due to the latitude. Thus between Eureka, on the northwest coast, and San Diego, at the extreme southern end of the state, equivalent to the difference between New York and Savannah, the mean annual temperature difference is only about ten degrees.

Temperature variations in California are far more a question of topography than of latitude. During the summer it is not unusual to find a difference of 30 to 40 degrees in the maximum temperatures on the same day between a coast station and a station 100 miles inland. Thus when at San Francisco the maximum temperature may be under 60 degrees it might reach 100 degrees in Sacramento or Fresno; while at San Diego, 500 miles south, it would probably be not more than 10 degrees warmer than in San Francisco. Much greater differences might be noted for some of the stations in the southeastern desert, where temperatures of 130 degrees have been recorded, with a monthly average temperature of 100 degrees. The lowest temperature in the state is in the High Sierra, where temperatures of about minus 30 degrees have been recorded.

Even a few miles are sufficient to make a great difference. Thus at Stanford University, about 30 miles south of San Francisco, the mid-day temperatures during the summer are usually from 10 degrees to 20 degrees higher than in San Francisco. This is due solely to the fact that the former is protected from the sea by a range of mountains shutting off the fog and much of the ocean wind to which San Francisco is fully exposed.

To a visitor from the eastern states the climatic conditions so totally different from those to which he is accustomed, are rather perplexing. Throughout the Pacific coast the year is divided practically into two seasons, the wet or winter season and the dry summer. To quote Bret Harte:

> **Warm and wet, and drear and dry,**
> **Half a year of clouds and flowers,**
> **Half a year of dust and sky.**

These differences are much more pronounced in California than in the regions further north, and the annual precipitation falls off very rapidly as we proceed southward. Eureka, on the northwest coast of California, has more than four times as much rainfall as San Diego, on the extreme southern coast (the annual means: Eureka 46.04 inches, San Diego 9.52 inches).

In a sense the seasons are reversed when compared with those of the Atlantic states, as the summer, except in the northern areas and in the mountains, is almost completely a dormant period for vegetation. Of course, in the regions of heavy snowfall and severe cold, vegetation comes to a standstill in the winter, but in the lower elevations there is never a complete cessation of plant growth. Even in regions where there is an abundant summer vegetation, as in the Sierras, this mainly depends for its maintenance upon water in the soil derived from melting snow, as summer rains are of rare occurrence anywhere in the state. This long dry period, lasting sometimes in Central California for upwards of six months, no doubt accounts for the predominance of xerophytic plants in California. A large proportion of the trees and shrubs are evergreen, and conifers are the dominant forest trees. Among the herbaceous plants there is an extensive development of annuals, which germinate with the first rains and complete their growth before the dry months. Another type of herbaceous plants is seen in the very numerous bulbous and tuberous species, especially members of the lily family. The awakening of vegetation begins not in the spring, but in the fall with the advent of the first winter rains. With the cessation of rain in April or May vegetation goes to rest for the summer.

The conditions governing the rainfall in California are similar to those controlling the temperature, and are largely topographical. As in the temperatures there is an extraordinary difference in the rainfall at different points in the state. Some northern stations may have more than 100 inches in a year, while in the desert in the southeast, a year may pass with practically no rain at all. The highest mean annual precipitation given by McAdie is 81 inches at Upper Mattole, in Humboldt County, on the northwest coast, but in some years the rainfall exceeds 100 inches, and he notes one annual rainfall of 120 inches, at Laporte in 1896. At one station in the southern desert, Mammouth Tank, the mean annual rainfall is only 1.81 inches, while in some years practically no rain at all has fallen.

While in general, as we have seen, the rainfall diminishes southward, there may be a great variation between stations only a short distance apart, due to the topography. Thus at Boulder Creek in the Santa Cruz Mountains, about 25 miles distant from Palo Alto, there is over three times as much rain as falls at the latter place.

These differences in humidity are plainly reflected in the vegetation

FIG. 1. DENSE FOREST IN THE UPPER CANYON OF THE SACRAMENTO, NEAR MT. SHASTA.

in different parts of the state. In the cool humid coast region of the north are found the tallest trees in the world, the redwoods, while the density of these redwood forests is hardly equalled anywhere in the world. On the other hand, certain regions of the intensely hot and arid deserts of the southeast corner of the state can support no vegetation at all, and others not quite so arid have only the scantiest flora, composed of such extreme xerophytes as the cacti, creosote bush and palo verde.

The peculiar topography of California is therefore largely responsible for the distribution of its flora. In the middle region are the three parallel ranges of mountains, the outer and inner coast ranges and the

great range of the Sierra Nevada. At the north these ranges come together in a transverse range, the Siskiyous, between California and Oregon; and towards the south is a similar transverse range, the Tehachapi. Between these mountain ranges are numerous valleys, of which by far the most important is the great Central Valley, drained by the Sacramento and San Joaquin Rivers, and extending for half the entire length of the state.

The outer coast range receives the full benefit of the moisture-laden winds from the ocean, while the valleys lying inside of the range are very much drier, and this is still more marked in the great Central Valley and in the regions south of the Tehachapi, most of which are really deserts.

The outer ranges are only of moderate elevation, but in the Sierras are the highest peaks in the United States proper, while in Death Valley and the Colorado Desert are areas lying 300 feet below sea level. This gives a range of elevation in California of nearly 15,000 feet.

Combined with these extraordinary differences in elevation is an equally marked variation of soil conditions, suitable practically for every sort of plant.

Corresponding to the extraordinarily diversified conditions prevailing in California, it is not to be wondered at that the flora of the state presents a variety quite astounding to the botanist accustomed to the comparatively uniform vegetation of the Atlantic half of the country. Whereas in the regions east of the Rockies there are no important barriers to the free migrations of plants, aside from questions of temperature and moisture, in California there are many barriers against such migration, and one finds within the limits of the state distinct floras

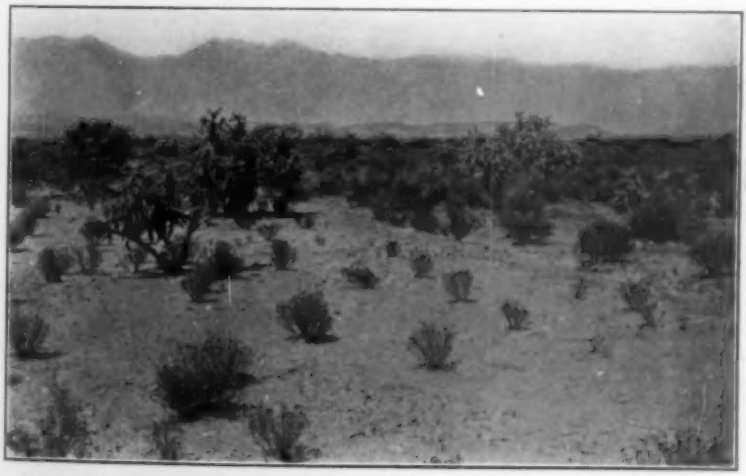


FIG. 2. DESERT NEAR TUCSON, ARIZONA. (Photo. Dr. W. S. Cooper.)

FIG. 3. REDWOOD FOREST NEAR STANFORD UNIVERSITY. (Photo. Robinson & Crandall, Palo Alto.)

which differ much more widely from each other than any that could be found in the Atlantic half of the country. In the well-watered areas of Atlantic America, lying east of the great plains, there are many species that range practically over the whole area. Such trees as the white elm, oaks of several species, maples and hickories extend over pretty much of this whole area, and the same is true of many other plants, so that the flora is very similar throughout the range, the main differences being the addition of new species to the northern flora in the moister and warmer regions of the southern states, and the disappearance of certain boreal types.

In California, however, the difference between certain floras is absolute. Thus the contrast between the dense redwood forests of the north, where the vegetation is fairly tropical in its luxuriance, and the flora of the Colorado and Mojave Deserts, parts of which are absolutely destitute of vegetation, is about as complete as it could well be; and except for a few species of aquatics, such as the cat-tails of the marshes and ditches, it is doubtful if the two regions have a single species in common. Even within quite short distances one finds a remarkable difference in the type of vegetation, due to rapid changes in elevation, as in ascending the slopes of the Sierra Nevada, or to differences in soil and moisture, as in the transition from the redwood forests of the outer coast ranges to the flora of the open valleys lying east of the mountains.

In the mountains to the west of Stanford University, a distance of less than 10 miles, there is a very heavy growth of redwood, with the accompanying mesophytic flora, largely made up of northern types, *e. g.,* brambles, ferns of several species, lilies, violets, wood-sorrel, clintonia, lady slippers, trillium and other types quite familiar to the eastern botanist. These northern plants sometimes follow the beds of streams flowing into the valley, but the floor of the valley is for its most part only sparsely wooded, mainly with oaks—quite different from the eastern species, especially the characteristic live oak (*Quercus agrifolia*), which is so prominent a feature in the valley landscape of the coast region of California.

In places the open ground is covered with a growth of chaparral (dense scrub) made up of a variety of species. Among these are the poison-oak (*Rhus diversiloba*), the California buckeye, a woody composite (*Baccharis*), the toyon (*Heteromeles*), and other unfamiliar-looking shrubs. The open ground not occupied by the chaparral supports a growth of annual grasses, among which in the spring are masses of wild flowers, mostly annuals, but comprising a number of perennial species, especially bulbous Liliaceæ. These are mostly genera poorly represented in the eastern states (*e. g., Lupinus, Trifolium*) or else entirely different genera, *e. g., Gilia, Godetia, Orthocarpus,* and many others. These latter are most of Mexican affinities, but a good many

genera are peculiar to California. Later in the season and persisting until the autumn, are a small number of flowering annuals, mostly Compositæ. Among these perhaps the most characteristic are the tarweeds of the genus *Hemizonia*.

As an example of change due to elevation, with, of course, accompanying increase in precipitation, the ascent of the Sierra Nevada from the great central valley is very instructive. This great valley has a scanty rainfall which is often insufficient for any tree growth away from the streams, and the level floor of the valley reminds one of the prairies of the middle west. The foothills develop a scattered growth of oaks, and a little higher up one finds the peculiar digger pine (*Pinus Sabiniana*). Somewhat higher up the yellow pine (*P. ponderosa*) appears, and at elevations of about 4,000 feet, that of the Yosemite, the open forest of the Sierras is well developed; but one must ascend still higher, about 6,000 feet, to see the fullest development of this wonderful forest as one finds it in the belt where the giant Sequoias grow. Here among the huge conifers is a rich growth of deciduous trees, oaks, maples, dogwoods and others, and many beautiful flowering shrubs and herbs. Along the streams and in the low ground are sub-Alpine meadows, in which grow a great variety of beautiful flowers—lilies, asters, orchids, painted-cups, the great hellebore (*Veratrum*), columbine, lupins, gentians, lark-spurs, monk's hoods, and many other showy species.

The forest is well developed up to about 8,000 to 9,000 feet, above

FIG. 4. FOOTHILLS OF SANTA CLARA VALLEY NEAR STANFORD UNIVERSITY. (Photo. Robinson & Crandall, Palo Alto.)

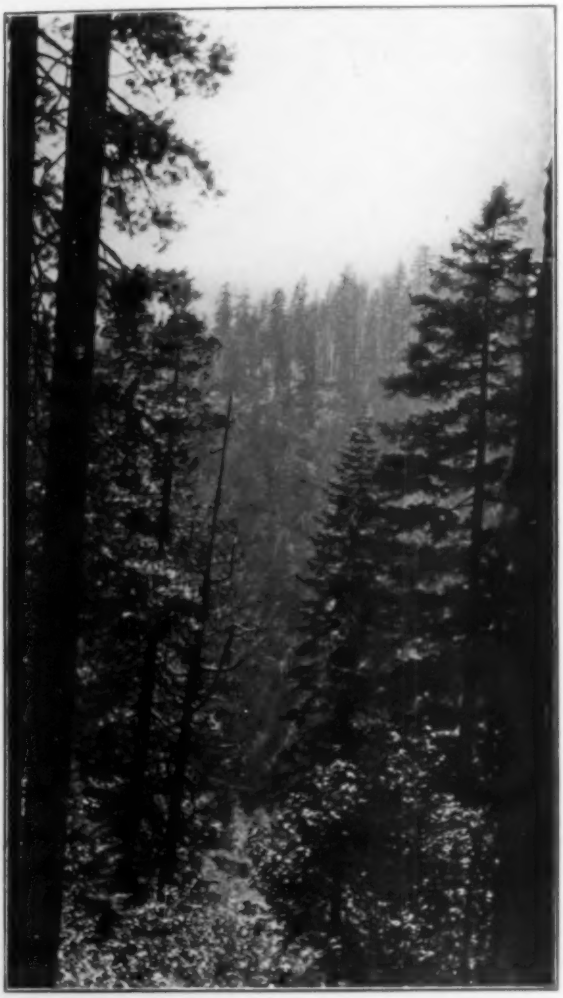


FIG. 5. CONIFEROUS FOREST NEAR MT. SHASTA. Douglas fir predominant.

which only such Alpine trees as *Pinus albicaulis* and *P. flexilis*, and the western juniper occur, hugging the ground and braving the tempests of the exposed summits.

Many species in California are extremely limited in their range, such as the fan palms (*Washingtonia*) found in a few cañons opening into the Colorado Desert; the great bush poppy (*Romneya*) of Southern California; and perhaps best known of all the several local coniferous trees, of which the Monterey cypress and Monterey pine, confined to a few miles of coast near Monterey, are the best known.

Origins of the California Floras

The southern part of California is geographically part of the Mexican plateau, and the plants are largely the same as those of the adjacent regions of Mexico, Lower California and Arizona. This is a more or less pronounced desert area, and the characteristic plants are most of them well adapted to resist long periods of drought. Shrubs with small tough leaves or almost leafless, like the "palo verde" (*Parkinsonia*), are characteristic of this region, and in many parts of it the cacti reach a great development. Mesquit (*Prosopis*) and yuccas of various species are also features of this region, as well as a good many annuals, which are particularly abundant in years of good rainfall.

Fig. 6. Desert near Tucson, with Giant Cactus, *Cereus giganteus*. (Photo. Dr. W. S. Cooper.)

In the mountains, with the increasing moisture in the higher elevations, a forest develops but much less luxuriant than that of the northern part of the state. One of the most striking types found in the southeast part of California is the palm, *Washingtonia*, already referred to. This is the only palm growing native within the limits of the state.

Many of these Mexican types, of both woody and herbaceous plants, extend northward through the drier valleys and along the mountain slopes to the extreme north part of the state.

Going northward, however, especially in the cool, moist regions of the coast ranges and the high Sierras, plants of a very different character begin to be abundant, and it is evident that these are plants of northern origin, and one encounters many genera familiar to the eastern botanist. Roses and brambles; huckleberries, rhododendron and azaleas; maples

and dogwoods; lilies, violets, trilliums, buttercups and other northern genera are common. Owing to the coolness and moisture of these outer coast ranges, many of these northern types, following the mountains south, reach well beyond middle California.

In this region there is a mingling of the northern and southern floras, which is particularly well illustrated in the regions about San Francisco Bay, where the northern types as a rule occur in the redwood belt, and in the shady cañons where there is an abundance of moisture, and lower temperatures than prevail in the open valleys and on the exposed slopes of the mountains. In the latter areas there is a predominance of southern species.

A characteristic form of this southern xerophytic vegetation is seen in the "chaparral," the dense scrub which covers the exposed hillsides and, also, to some extent, the floor of the valleys. This is well developed in the neighborhood of Stanford University, where the chaparral includes dwarf oaks, wild lilac (*Ceanothus*), manzanita (*Arctostaphylos*), species of wild currant, roses, a large shrubby composite (*Baccharis*), "yerba santa" (*Eryodictyon*), buckeye, poison oak (*Rhus diversiloba*), *Garrya, Adenostoma,* and others. This "chaparral" very much resembles the similar formation "macchie," "maquis" of the shores of the Mediterranean.

The redwood formation, which is largely controlled by the amount of precipitation—including the copious summer fogs—comprises a number of characterisic species mostly of northern affinities. Thus with alders, maples, willows and dogwoods along the streams, there are evergreen oaks of a very different type from the eastern species, and other evergreen trees and shrubs, the most notable of which are the madroño (*Arbutus menziesii*) and the California bay tree (*Umbellularia*), forms which are quite unrepresented in eastern America. The most characteristic trees of the open valley are scattered oaks, of which two species predominate, the live oak (*Quercus agrifolia*) and the valley white oak (*Q. lobata*). These usually grow scattered about the valley and foothills, but sometimes on northern exposures they form associations that are sufficiently dense to be called forests. The open ground is largely occupied by a growth of annual grasses, among which grow a great variety of beautiful flowers like *Nemophila, Platystemon,* the California poppy, lupins and other annuals, but also including a number of perennial forms, especially the bulbous Liliaceæ such as *Brodiæa* and the beautiful mariposa lily (*Calochortus*). Growing with these native plants, especially where the ground has been cultivated, there are certain introduced weeds which occur in great numbers and contest the ground with the native plants. Among these introduced weeds may be mentioned the wild mustard, the "filaree" (*Erodium*) and the wild oats.

Along the shores of the bay are extensive salt marshes with a characteristic and interesting flora.

FIG. 7. *Azalea occidentalis.* A characteristic shrub of the moister forests.

A notable element in the Californian flora is one apparently of old world origin. In the northern coast region occur species like the Sitka spruce and western skunk cabbage (*Lysichiton*), which are also found in Kamtchatka; another old world genus is *Fritillaria*, of which species occur all the way from Alaska to San Diego, and one extends eastward as far as the Yellowstone Park. Of broad-leaved trees, the tan-bark oak

FIG. 8. CHAPARRAL FORMATION, LAKE TAHOE. The predominant shrubs, manzanita and species of *Ceanothus*.

(*Pasania densiflora*) is the only American representative of a genus largely developed in tropical and subtropical Asia, and the madroño (*Arbutus*) is also an old world genus which is not found in Atlantic America. Of herbaceous plants an interesting example is seen in the genus *Trientalis*, of which there is in eastern America a well-marked species, but the Pacific coast form is a variety of the old world *T. Europæa*. Whether these Eurasian types are comparatively recent immigrants, or whether they are relics of the old tertiary floras which have persisted on the Pacific coast, is not quite clear.

There are also examples among the lower plants, which apparently have had a similar origin. Among these may be cited the giant horsetail (*Equisetum maximum*), the fine fern *Woodwadia radicans* and a liverwort, *Targonia hypophylla*.

FIG. 9. *Ceanothus* sp. A characteristic chaparral shrub.

The seashore of California has a varied and extremely interesting flora. There are extensive sand dunes and beaches, as well as bluffs and rocky headlands. Among the striking plants of the dunes may be mentioned the tree lupins, species of *Mesembryanthemum*, the sand Verbena (*Abronia*), many showy Compositæ and others. Probably to the botanist the most striking features of this coast region are isolated groves or "islands" of conifers, of which there are several species of extremely limited range. The Monterey pine (*Pinus radiata*) and the Monterey cypress (*Cupressus macrocarpa*) are the best known.

Inside the shore zone lies, in middle and northern California, the outer coast range which sometimes comes close to the sea. Where the exposures to the strong ocean winds are not too great there is developed

in these coast mountains one of the most remarkable forests in America, and probably in the size and density of the tree growth one that is unequaled in the world. The predominant tree of this region is the coast redwood (*Sequoia sempervirens*), even surpassing in height its great cousin of the Sierra forests. In its northern ranges there are pure stands of these giant trees of extraordinary density, but southward the forests are usually more open and there is an intermixture of species, including the Douglas fir, *Torreya*, tan-bark oak, madroño and some other species. The limits of the redwood belt are practically determined by the sea fogs which prevail along the coast during the summer season. This fog takes the place of summer rains, and the vegetation of the redwood belt is largely mesophytic in character, with a predominance of northern genera. On the inner slopes of the ranges the moisture is usually insufficient to support a heavy growth of redwoods, and where they disappear they are replaced by shrubs and trees of a more xerophytic type, and these also largely disappear on the dry floor of the valleys.

In Central California there is a second range, the inner coast range, parallel to the outer one, and between these are numerous sheltered valleys, often of great fertility; while between the inner coast range and the Sierras lies the great central valley drained by the Sacramento and San Joaquin Rivers, which break through the inner coast range and discharge their waters together into San Francisco Bay.

These valleys have only a moderate rainfall, especially the great central valley, and those further south, and there is only occasionally developed in these associations of trees that can properly be called a forest. The floor of the valley and the lower foothills are usually covered with a growth of annual grasses, and where the uncultivated areas have been left we find in spring a profusion of the showy annuals and bulbous plants already referred to.

To the botanical student, probably the most interesting elements of the Californian flora are the conifers, which in size and variety surpass those of any other region in the world. These conifers reach their greatest development on the west slopes of the Sierras of Middle California at an elevation of some 4,000 to 6,000 feet. In this belt grow the giant Sequoias, accompanied by several other species, of which the most prominent are the yellow pine (*P. ponderosa*), the sugar pine (*P. lambertiana*), the white fir (*Abies concolor*), the incense cedar (*Libocedrus decurrens*), and the Douglas fir (*Pseudotsuga taxifolia*), all trees of gigantic size. At higher elevations other species supplant these to some extent, and altogether there are about 60 species of coniferous trees in the state, a larger number than occurs over all the rest of the United States.

True Alpine floras occur in the higher elevations, above 9,000 feet, but are less developed than in the moister regions further northward, as

in the Cascade ranges of Washington and the Canadian Rockies; but there are, nevertheless, many very beautiful true Alpine forms, such as the species of *Bryanthus*, gentians, phlox, primroses and various others.

The sub-Alpine flora is well developed wherever there is sufficient moisture, and the wet meadows full of brilliant flowers are very beautiful.

FIG. 10. CONIFEROUS FOREST, LAKE TAHOE. The tall tree is white fir (*Abies concolor*), the predominant species in this region. Note the man standing near the base of the tree.

FIG. 11. SUGAR PINE (LEFT), RED FIR (*Abies magnifica*) (RIGHT). Near Lake Tahoe, about 6,500 ft. elevation.

While most of California north of the Tehachapi range has an adequate rainfall, the southern part of the state, except near the coast, is largely a desert, and in some parts deserts of the most pronounced character, as in Death Valley and parts of the Colorado Desert.

The flora of this region, as we have already indicated, is mainly Mexican and has very little in common with much of the northern part of the state.

FIG. 12. YELLOW PINE (*Pinus ponderosa*). Near Mt. Shasta, elevation about 3,000 ft.

A marked feature of most of Californian plants is their "xerophytic" character, *i. e.*, their adaptation to long periods of drought. This is conspicuous in the trees, which are largely conifers or else broad-leaved evergreens, like the live oak, madroño and laurel. It is also marked in very many of the shrubs, which have small evergreen leaves. The shrubby plants making up the "chaparral" are largely evergreen, *e. g.*, wild lilac, the manzanita, chinquapins, dwarf oaks and others.

Owing to the isolated position and numerous barriers within the state, California presents an extraordinarily large number of "endemic" or peculiar species, some of which are of very limited range, such as the peculiar conifers of the coast region. I have not been able to find any tabulation of the proportion of the endemic species, but it

FIG. 13. INCENSE CEDAR (*Libocedrus decurrens*), LAKE TAHOE.

certainly must be very much greater than that of any other part of the United States. The marked development of endemism is seen in very many large genera, such as *Calochortus, Lupinus, Trifolium, Gilia* and various others. The majority of these species is exclusively Californian. Thus in the genus *Lupinus* about half of the known species are found in California, and a large majority of these is peculiar to the state.

Many species are extremely variable and the limits of species difficult to determine. California should be an exceptionally favorable region for studying variations under natural conditions. Perhaps some light might thus be thrown upon the vexed question of "mutations," and other factors concerned in the origin of species.

INDUSTRIAL RESEARCH IN AMERICA[1]

By RAYMOND F. BACON

DIRECTOR OF THE MELLON INSTITUTE OF INDUSTRIAL RESEARCH OF THE UNIVERSITY OF PITTSBURGH

EVEN before the United States became a republic, some interest in industrial research was manifested.[2] This is evidenced in the preface to the initial volume of the *Transactions of the American Philosophical Society,* published in 1789, in which the aims of the society were presented. Among these were "making useful discoveries that would . . . promote the interest of the country." The earliest contribution to chemistry from this country, bearing the date September 10, 1768, appears in the *Transactions* of this society under the title "An Analysis of the Chalybeate Waters of Bristol in Pennsylvania," by John de Normandie.

The principal object of the Chemical Society of Philadelphia, which was founded in 1792 and was thus the first chemical society in the world, was to secure information relating to the minerals of the United States. A standing committee of five chemists was charged with the duty of analyzing any mineral which might be submitted to it, provided it was forwarded free of expense, with an account of the locality and situation in which it was found. The analyses were made without charge. In 1799, this society also gathered information relating to the manufacture of niter, acquainted the public with the uses of various minerals, and encouraged the manufacture of pottery. Evidence of the interest which was evinced at this time in ceramics may be found in an oration delivered by Felix Pascalis before the Chemical Society of Philadelphia in 1801. This savant said:

> Encourage and repeat mineralogical experiments on all kinds of alumine. The first who will successfully procure manufactured works of the kind and tolerably good earthen wares will deserve well of his country and be rewarded by the gifts of fortune.

Early Industrial Researchers

Among the earliest American scientists who became interested in the chemistry of manufacturing processes was James Woodhouse, professor

[1] Excerpts from a public address delivered at the Columbus, Ohio, meeting of the American Association for the Advancement of Science, December 29, 1915.

[2] It may be noted here that the first manufactures in colonial America—glass in 1610 and leather in 1630, both of which were established in Virginia—were chemical in nature.

of chemistry in the medical department of the University of Pennsylvania from 1795 to 1809. Woodhouse was the first to demonstrate the superiority of anthracite over bituminous coal "for intensity and regularity of heating power." Contemporaneous with this chemist were the following: Robert Hare, the inventor of the oxyhydrogen blowpipe (1802), who obtained calcium carbide, phosphorus, graphite and calcium by the aid of electricity, and is to be regarded as the earliest American experimenter in electrochemistry; Joseph Cloud, assay master at the Philadelphia Mint, who, in 1807, made an interesting research—the first in metallurgy in this country—on a native alloy of palladium and gold from Brazil; John Harrison, the first manufacturer of sulphuric acid in this country (1793), who was an ingenious industrialist and made a number of technical innovations in practise; and Gerard Troost, professor of chemistry at the University of Nashville, who established works for the production of alum at Cape Sable, Maryland, in 1814.

Considerable industrial research was carried on in the United States from 1820 to 1860. James Cutbush, professor of chemistry at West Point, made a number of valuable contributions to scientific pyrotechnics, but is chiefly remembered for his description, published in 1822, of the production of cyanogen by the action of nitric acid upon charcoal. Our first prominent industrial chemist, Samuel Guthrie, of Sackett's Harbor, N. Y., discovered chloroform, engaged in the manufacture of fulminating compounds, and devised a commercial process for the rapid conversion of potato starch into sugar (1832). Our first real metallurgical chemist, W. W. Mather, of Columbus, Ohio, made an elaborate research on the principles involved in the reduction of Mexican silver ores, in 1833. Lewis Feuchtwanger, who was well-known to the chemists of this period by his commercial establishment for the manufacture and sale of "rare" chemicals, devised, in 1837, an expeditious method for the manufacture of vinegar and later, in 1872, studied the process of glass-making. Then there was S. L. Dana, of Lowell, Mass., who was, for fifty years, the acknowledged authority in the United States on technical chemistry. After the completion of his medical studies in 1818, Dana soon devoted himself to manufacturing chemistry, holding the position of chemist to the Merrimac Print Works from 1833 to 1868; he invented the "American system" of bleaching in 1838, and was also an authority on manures and lead poisoning.

Among the other chemists of this period who busied themselves in the domain of industry were: J. C. Booth, of Philadelphia, Pa., noted for his work on beet sugar (1842), the production of gelatin (1842), the nickel ores of Pennsylvania (1856), and illuminating oils (1862), as well as for being the founder of an active firm of chemical consultants; John Dean of Boston, Mass., who investigated the value of different

kinds of vegetable foods in 1844; David Alter, of Freeport, Pa., the discoverer of spectroscopy, who began the manufacture of bromine in 1846 and later became a coal-oil technologist; Charles Lennig, an industrialist of Philadelphia, who was the first to manufacture bleaching powder in the United States (1847) and afterwards (1869) introduced the manufacture of hydrochloric acid by modern methods; L. C. Beck, professor of chemistry in Rutgers College, who made valuable observations respecting bleaching and disinfecting compounds and was an authority on bread-stuffs (1848); A. C. Twining, a chemical engineer of the fifties, who invented an ice machine; A. A. Hayes, of Brookline, Mass., a productive student of the Bessemer process (1852); C. M. Wetherill, who conducted researches on illuminating gas in 1854 and on the manufacture of vinegar in 1860; Benjamin Silliman, Jr., the author of technochemical classics on Pennsylvania petroleum (1855), California petroleum (1865 and 1867), and on the combustion of fuel (1860); E. N. Horsford, a researcher of great ability who worked out processes for preparing phosphoric acid (1856) and was active in establishing markets for this product; Henry Wurtz, of New York, who played an important part in the development of the manufacture of glycerol in 1858; and J. M. Ordway, of the Massachusetts Institute of Technology, who investigated the manufacture of sodium hydroxide in 1858 and the manufacture of water-glass from 1861 to 1865.

Industrial Research from 1860 to 1880

The late Joseph Wharton, of Philadelphia, deserves especial mention in the history of technology in America. After some preliminary experiments, Wharton erected at Bethlehem, Pa., in the year 1860, a spelter works of 16 Belgian furnaces, which produced over 3,700,000 pounds of zinc in 1862. The product was of excellent quality, and was made so cheaply as to afford a reliable profit and to plant the zinc industry firmly in the United States. Wharton first reduced silicate of zinc to metal on a large scale, successfully applied anthracite to the manufacture of spelter, and used American clays for making zinc retorts.

Many chemists rendered service to the advancement of industry during these two decades, and it is indeed difficult to designate the most prominent researchers. B. F. Craig, of the laboratory of the Army Medical Museum at Washington, D. C., worked in the field of explosives and, during the period 1861–1864, made a number of contributions to our knowledge of gunpowder. Frederick Hoffmann, of New York, was an authority on organic colors and medicinal chemicals. C. A. Goessmann, of the Massachusetts Agricultural College, contributed to the manufacture of salt (1863), the refining of sugar (1864), and the pro-

duction of beet sugar (1872). F. H. Storer, of Harvard University, made researches on the alloys of copper and zinc in 1864 and on petroleum in 1865.

While charged with responsible duties of administration, Charles F. Chandler, at present the honored dean of American chemists, was always productive in research. His early researches of technical importance were those on water for locomotives (1865), the water supply of New York (1868 and 1870), the purification of illuminating gas (1870), kerosene (1871), and the manufacture of condensed milk (1871). Another chemist who was called upon by the gas industry was Henry Wurtz, who made improvements in the methods of purifying water-gas (1867) and, jointly with Silliman (1869), elucidated the processes of manufacture.

The noteworthy researches of S. F. Peckham on asphalt and petroleum were carried on from 1867 to 1874. W. H. Chandler, who, with C. F. Chandler, edited the *American Chemist*, contributed to the purification of zinc containing iron (1869) and to the refining of iron (1870). J. B. Britton, chemist to the "Iron Masters' Laboratory," performed a great amount of technical work in ferrous metallurgy. S. Dana Hayes, state assayer of Massachusetts, studied the destructive distillation of naphtha in 1871 and was recognized as an expert in petroleum technology. Isidor Walz, of New York, was a textile expert. C. U. Shepard, Jr., of Charleston, N. C., an authority on fertilizers, investigated the effects of sulphur dioxide on vegetation in 1872. Henry Morton, of Stevens Institute, had occasion to conduct an extensive series of researches on petroleum from 1872 to 1874. J. P. Kimball, of Lehigh University, engaged in work in the manufacture of iron and steel, and found uses for emery in the iron industry (1873). The Nestor of the mining engineering profession, R. W. Raymond, investigated the calorific value of lignites in 1873. J. F. Babcock, of Boston, Mass., carried out researches which established him as an expert on wood preservation. T. M. Drown, professor of chemistry at Lafayette College, was the author of important papers on the blast furnace, the puddling and Bessemer processes, and the conditions of carbon in gray and white pig iron. H. M. Pierce was most active in the promotion of the interests of the wood distillation industry. C. E. Avery, of Boston, Mass., laid the foundation for the manufacture of lactic acid. Charles and Nelson Goodyear and A. G. Day, known for their inventions in connection with india rubber, may also be included among the industrial researchers of this period.

Industrial Research During the Last Three Decades

Sufficient has been presented to show that American scientists have, from the inception of the republic, been constantly engaged to a greater

or less degree in original investigations of the problems of manufacturing. Time will not permit the recounting of the many valuable contributions which have been made by the chemical profession during the most modern period of our industrial history, from 1880 to the present time. With your permission, I shall, however, refer to some of the most noteworthy researches.

The first electrochemical enterprise to be established at Niagara Falls was that of the present Aluminum Company of America for the manufacture of aluminum according to the process of Charles M. Hall. It was indeed remarkable that, after all the attention which had been given to aluminum, it remained for this young Oberlin graduate to devise the process by which 50,000 metric tons are now being produced annually in the United States and Canada. Hall possessed all the characteristics of an inventive genius.

Another distinguished electrochemist, H. Y. Castner, invented processes for the production of sodium and sodium hydroxide; while E. G. Acheson has discovered carborundum, artificial graphite, deflocculated graphite, and siloxicon. Both of these pioneers in modern electrochemical research succeeded in founding great manufacturing establishments, monuments to their rare investigative ability. Other chemists who have engaged with success in this field are the following: C. E. Acker, who devised a process for the manufacture of sodium hydroxide and bleaching powder which differs from the Castner process; W. T. Gibbs and S. P. Franchot, who invented a commercial process for the electrolytic production of potassium chlorate; T. L. Willson, who was the pioneer in the manufacture of calcium carbide and acetylene; Isaac Adams, the inventor of nickel-plating; and E. R. Taylor, who worked out a resourceful method for the commercial production of carbon disulphide.

Other brilliant inventors in the domain of chemical industry have been Herman Frasch, whose most valuable processes relate to the refining of petroleum and to the extraction of Louisiana sulphur; Waldron Shapleigh, who worked up methods for the extraction of the rare-earths from monazite; Thomas A. Edison, who, among many other things, first evolved a successful system of incandescent electric lighting; Charles Steffen, the deviser of the process for working over the mother liquors in beet-sugar manufacture; the Hyatts, who founded the great nitrocellulose industry; Arno Behr, who had such an active part in the development of the great corn-products industry; and J. B. F. Herreshoff, the eminent copper metallurgist and chemical engineer. These are a few of the researchers who have played a prominent part in the establishment of our industrial prosperity.

The Present Industrial Activity of the Chemist

If it is conceded that chemistry is the intelligence department of industry,[3] one may therefore conclude that the measure of the influence of the profession of the chemist upon the industrial development of our country constitutes *per se* an index of the value of research to manufacturing. I have pointed out in another place[4] that the measure of a country's appreciation of the value of chemistry in its material development and the extent to which it utilizes this science in its industries, generally measure quite accurately the industrial progress and prosperity of that country.

Early American Chemical Industries

Manufacture	First Manufacturer	Year	First Important Improvement	By Whom	Year
Sulphuric acid....	John Harrison, Philadelphia, Pa.	1793	Platinum still for concentrating.	John Harrison.	1814
Gunpowder.....	E. I. du Pont de Nemours, Wilmington, Del.	1802	Manufacture of potassium nitrate from sodium nitrate.	Du Pont Company.	1868
White lead.....	S. Wetherill & Son, Philadelphia, Pa.	1804	The use of cheaper material from Mo. and Ill.	———	1850
Pharmaceutical chemicals.....	Rosengarten & Sons, Philadelphia, Pa.	1823	Production of ether and quinine, 1823; morphine, 1832; strychnine, 1834.	Rosengarten & Sons.	—
Varnish.....	P. B. Smith, New York, N. Y.	1828	Improvement of quality to create a foreign market.	P. B. Smith.	1836
Wood distillation.	James Ward, North Adams, Mass.	1830	Manufacture of acetate of lime and wood alcohol.	J. A. Emmons and A. S. Saxon.	1867
Nitric acid.....	Carter and Scattergood, Phila., Pa.	1834	Distillation apparatus.	Edward Hart.	1898
Hydrochloric acid.	Carter and Scattergood, Phila., Pa.	1834	Manufacture by modern methods.	Charles Lennig.	1869
Chlorine.....	Charles Lennig, Bridesburg, Pa. (bleaching powder).	1847	Commercial process for the electrolytic decomposition of sodium chloride.	E. A. LeSueur.	1893

[3] This statement should not give rise to an impression that the contention is that the industrialist relies *absolutely* upon the chemist. The technical demands made by modern manufacturers are extensive and exacting, and sole reliance upon the chemist would be oftentimes fatal to the realization of success. The aid of other industrial specialists must always be called in during the course of development.

[4] *Science*, 40 (1914), 871–81.

The public has been left to its own resources to determine the function of that industrial scout, the chemist. This condition has been briefly explained by one chemist:

> Our public work is obscured by impenetrable technical detail and our industrial achievements are cut off from public view by high factory walls.

A large percentage of the 10,000 chemists of the United States do labor under cover, yet these 10,000 men—about 25 per cent. of whom are engaged in industrial research, the others in control work—are actively occupied in manufactures which affect over 1,000,000 wage earners and produce over $5,000,000,000 worth of products. As Hesse[5] has quite convincingly demonstrated, in the case of thirty-one American industries, the chemists employed therein directly affect 24.6 per cent. of our manufacture values and 20.2 per cent. of our values added by manufacture. They are constantly engaged in the development of processes and in refining methods of control or of manufacture.

The Evaluation of Industrial Research

However, many industrialists are even now certain that research will not pay. Some regard their technology as a hereditary art. Some have favorable raw material conditions or a large demand for their products, and are therefore disinclined to invest a very small portion of their earnings in a reserve of knowledge. Others have prospered because of high tariff, notwithstanding short-sighted management. But most of our industries are built upon stronger foundations. It is plain that the use of natural laws offers a more stable basis upon which to erect a manufacture and a more uniform source of profit than any structure built upon artificial conditions created by legislation. Moreover, the quality and value of a product are based upon the application of correct principles in its conception, preparation and use, and the correct principles can only result from scientific research. Ample support to this contention is to be found in the manufacturing operations of to-day.[6]

The Future of Industrial Research in America

Prophecy is a double-edged tool with a peculiar facility for injuring the user, but the activity of the present leads one to predict that each succeeding year will bring us nearer to the state in which the research work of the country will be national in both scope and effort. The federal government and the states have done and are conducting research of immense value to agriculture, the foundation of industry; but the future will witness a more general application of this principle—an active national interest in industrial research, and this will serve as a healthy

[5] *J. Ind. Eng. Chem.*, 7 (1915), 294.

[6] On the contributions of the chemist to American industry, see Hamor, SCI. MON., 1 (1915), 86; but especially Bacon, *Sci. Am. Suppl.*, 80 (1915), No. 2081, 334; and *Chem. News*, 112 (1915), 300.

subsidy for American manufactures. Research has enabled our industries to make rapid strides. The recognition of this fact has occasioned a recent awakening to an increased sense of appreciation of the need of greater facilities for insuring the scientific development and extension of industry and commerce and of promoting industrial research. Let us therefore proceed towards the adoption of this plan with unhalting step.

Our universities should make active preparation to assume their share of responsibility in this movement of national preparedness. There is too great a tendency in this country to regard intellectual men as a class apart from business men and especially from industrialists. It is a well-known fact that the German university has been one of the most anarchic of institutions, both the professorate and the students having had greater freedom than in the American universities; and at the present time Germany owes more to its universities as they have been conducted in the past than to its army as it is now organized.[7] In Germany there are captains of the intellectual group as well as of industry and of the military.

We must make ourselves self-sufficient. Some steps have been taken by the government, as, for example, in the formation of the Naval Advisory Board; but this is only a beginning. From the standpoint of real preparedness, the government should know exactly what her scientific and technical experts could best do for American industrial welfare and for their country in the event of war, and full particulars should be available regarding the research laboratories in the United States and the facilities thereof. American scientists are eager to render service to their country and to her industries.

A large industrial firm finds it advantageous to spend about 4 per cent. of its gross annual income on research, in providing for its future welfare and for keeping ahead of its competitors. On the same basis, if the United States expends $400,000,000 annually on its army and navy, it could, with profit, spend $16,000,000 a year on research. An equal sum, spent in the construction of a superdreadnaught, may be either an advantage or a loss; the research of carefully selected scientific men could be only an asset.

All this suggests the formation not only of a great national research laboratory, but also of a central bureau, in, say, the Federal Department of Labor, which would apply trained men to learn what American scientists are doing, their specific fields of investigation, and the equipment and research facilities of their laboratories, as well as to ascertain the problems of the various industries. This bureau could then put industrialists in touch with active university researchers, with the result that there would be an extension of both *useful* scientific investigation and manufacturing efficiency.

[7] See Cattell, *Pop. Sci. Mo.*, 87 (1915), 311.

THE PRESENT STATUS OF THE ANTIQUITY OF MAN IN NORTH AMERICA

By Dr. CLARK WISSLER

AMERICAN MUSEUM OF NATURAL HISTORY

THE passing of that veteran anthropologist, Professor Frederic Ward Putnam, the culmination of Professor Henry Fairfield Osborn's researches in his "Men of the Old Stone Age," and Professor J. C. Merriam's recent exhaustive review in *Science* of the evidences for the early presence of man in California, all combine to make the serious reconsideration of man's antiquity in America a scientific necessity. Without in any way disparaging the valuable contributions of others, the progress so far made may be said to stand as a historical memorial to Professor Putnam, who, in spite of long years of almost barren search, still held firmly on to such faint glimpses of man's antiquity as chance threw in his way. This is not the place to record the history of these researches or to extensively review the formative work of Holmes, Abbott, Volk and others, but some characterization of the problem as it was left by these investigators is possible at this time. The extraordinary triumphs of anthropological research in western Europe naturally lead to measuring American data by these standards. When we take a comparative attitude toward the two, one striking contrast appears, for, while in Europe one finds definitely stratified superimposed beds rich in animal, human and cultural remains, in America we have little more than isolated finds, a stone implement here or a bone there. Some of these finds have called forth a surprisingly large controversial literature and still find places in our standard reference books because no satisfactory conclusion can be reached in the absence of associated faunistic or other chronological indices. Of skeletons, the celebrated Lansing man is typical. The difficulty with it is that no satisfactory faunistic or cultural associates were found and no precise way for dating the river terrace in which the bones were found has appeared. Further, the anatomical characters of the Lansing man are not distinctly different from the known American types; if they had so differed we should have had at least one argument for their antiquity.

Some writers have given undue weight to the fact that all the skeletons so far presenting claims to antiquity are of the American Indian type and so can not be ancient. This is really a fallacy, for while the presence of a distinct morphological difference would be one good argument

for a respectable antiquity, the absence of such differences would not be equally good evidence against it. Thus in Europe we find an early type known as the Crô-Magnon, which has its close parallels in the present population. Then the indisputable unity of the whole American race from north to south leaves us no choice but to conclude that its ancestral stock came from one source, and that from the start its fundamental somatic characters were delimited. There are good faunistic reasons for believing that America received its population from Asia at a period comparing to the Paleolithic of western Europe, and that since the late Neolithic has remained in almost complete isolation. According to these interpretations, there is no reason to expect that any of our skeleton finds, however ancient, will show decided differences from the surviving types. These conditions rob us of one method by which a definite conclusion could be formed as to the antiquity of random skeletal finds. About the only anatomical check we can expect is in case such finds can be identified as belonging to local historical tribes, but even here we must proceed with caution, for the great persistence of local types in Europe indicates the possibility of the long continuance of initial types in the same habitat.

European investigators have achieved their greatest triumphs from discoveries of the débris of human cultures, but similar deposits have not yet come to light in America. The claims of Abbott, Volk and others have been based almost entirely upon random finds of stone or bone worked by man. The American literature of some twenty years ago is curiously characterized by affidavits and sworn statements, as to the exact place, position, identity, etc., of the single objects found. This itself effectively demonstrates the insufficiency of the data. While theoretically the finding of a single stone implement in an interglacial deposit would prove the contemporaneous existence of man, its very unverifiable nature would make it of little scientific worth, and the necessity of depending entirely upon the mere assertions of an individual would leave us no recourse but extreme skepticism. In contrast to the interglacial deposits of culture débris in western Europe, these random American finds too strongly suggest errors in observation and natural accidents of deposition to afford a basis for any kind of scientific or mere speculative structure.

It is true, of course, that the mere accumulation of these observations, isolated though they be, adds greatly to their weight and will, if long continued, give a sufficient basis for some kind of an interpretation. The only part of the country from which such an accumulation begins to appear is the Pacific coast of the United States, where Professor Merriam cites at least eleven different finds in Pleistocene and earlier formations. But notwithstanding the obvious fact that, given enough time, a very respectable series of artifacts may come to hand from the gravels of the Pacific slope, the difficulty of correlating them and of interpreting the

culture of the period is still very great. The experience with European deposits is decidedly against the successful use of such isolated finds. It seems a safe prediction that unless the original culture deposits can be found in the Pacific coast area, faunistically or otherwise dated, we shall always find it necessary to maintain a more or less skeptical attitude toward the antiquity of these isolated finds, even though they be of great number.

One difficulty we have not yet stated is analogous to that encountered in skeleton finds: viz., the lack of distinct differences between these supposed antiquities and objects found on the surface of recent village sites. As in case of skeleton material, the fact that certain differences can not be observed is no good reason for doubting their antiquity; it simply leaves us with an even chance that their presence in all geological strata is intrusive. The crucial point is that, notwithstanding the vast amount of searching by archeologists, amateur and otherwise, nowhere within these United States and Canada have we record of a culture deposit that clearly precedes or accompanies the last period of glaciation. As to what the future may bring forth no prediction is safe. It is probable that if the auriferous gravels of California do have human relics, stratified deposits will ultimately appear. This part of the country is still but newly occupied and may in the near future reveal rock-shelter deposits of undoubtable antiquity. On the Atlantic seaboard and in the limestone cavern area of the Mississippi Basin, there is much less reason to expect new discoveries, for the ground has been worked over with considerable care. The only site about which even a strong presumption of antiquity can be raised is at Trenton, New Jersey, where Dr. Abbott, and later Putnam and Volk, made certain observations, upon the basis of which a theory of stratification has been advanced. The Trenton site presents first a black sandy soil of some two feet in depth, below which is a layer of yellowish sand from one to three feet and resting upon gravels. In the black soil were remains clearly identified with those of the Delaware Indians, formerly occupying the vicinity. In the sand disconnected with the soil were random stone implements. By dint of long and patient search Mr. Volk discovered in the gravels beneath two fragments of human bones and one or two problematic pebbles, suggesting human workmanship, but not positively. On this basis Putnam assumed three culture periods for the Delaware Valley, the oldest preceding the last advance of the ice, the second during the final retreat of the ice, and lastly the historic period.

It will be noted that the data for the first period consist of little more than a single find and, as may be expected, have been looked upon with extreme skepticism. No faunistic associates were found in the gravels except a fragment of a scapula, which may be musk ox, though it can not be positively distinguished from bison or even domestic ox.

Altogether these are not adequate data for establishing a culture period. Fifteen years of subsequent observation by Mr. Volk have failed to bring anything more to light, and also, since it is not clear that the gravels in which these bones were found were undisturbed by post-glacial floods, we must consider the case as far from proved.

This brings us to the middle sand layer, which enjoys the distinction of being the only archeological find so far reported that has a fair claim to antiquity. Mr. Volk ran a series of trenches in one part of the site, discovering some fragmentary human bones and a number of stone implements. The variety of artifacts indicated a cultural difference from those found in the black soil above and as they appeared to be made from argillite, the assumed culture was designated as Argillite culture. After this definite result Mr. Volk did not trench further, but rested his case.

Mr. Volk's claim for the antiquity of this layer was generally rejected on assumed geological grounds. In brief, it was regarded as a wind deposit of comparatively recent formation, most of the artifacts having merely "settled" down from the black soil above. Failure to meet either of these objections would waive all just claim to antiquity. As no further trenching was reported, the case necessarily stood as not proven and interest in the site was lost.

After an interim of about ten years, Dr. C. C. Abbott, owner of the site and its original discoverer, invited the American Museum of Natural History to reexamine the deposit. This resulted in a more systematic investigation which gives us data of a more positive kind. The trial trenching was carried on by Mr. Alanson Skinner and the stratigraphic work by Mr. Leslie Spier. The report of Mr. Spier fully agrees with Mr. Volk's observations, but presents some new problems. Mr. Spier discovered that the vertical distribution of the artifacts in this yellow sand took the form of a normal frequency curve. It was then possible to compare with precision the series from the various trenches and also with the former data of Mr. Volk. By this triumph of method it was shown that through the deposit extends one plane of maximum frequency around which the artifacts fall in a normal frequency curve. Pebbles of appreciable size were found in the sand and two series for these showed that they also had the same frequency curve with approximately the same average. In other words, the series for artifacts is the same as the pebble series, the former being but worked pebbles. Hence, the same agency that deposited the pebbles also deposited the stone implements. While man could have carried the artifacts and dropped them on a wind-growing sand dune, it is inconceivable that he should have carried the pebbles, for they are many times more numerous than the worked stones. Further, a recent study of known wind and water deposits by a geologist shows that the normal frequency curve for

coarse grains of sand is characteristic of water deposits, but not of wind-carried material.

Therefore, the archeological brief for this case may be said to be in. It shows artifacts of stones deposited in a definite way agreeing with our present knowledge of water deposits. These artifacts are distinct from and below the cultural débris of the Indians living here at the discovery of America, and are therefore older. The age of the deposit is a geological problem which awaits further investigation, but as a water deposit it must be not later than the last recession of the ice from Northern New Jersey.

While this case has thus come to a definite pass and stands so far as the best evidence for an ancient culture in America, it still presents some of the characteristics noted at the outset. It also is in a sense a random deposit of isolated specimens, selected and carried by a natural agency. Under such conditions the cultural association of the objects can not readily be determined, and until a camp site of this culture is uncovered and identified there will be a general hesitancy to accept the result noted above. The case of the Delaware Valley is thus about the same as that for the Pacific coast, and in contrast to the condition in western Europe, where we have definite camp deposits, is rather disconcerting. At least it presents a serious problem that calls for new methods and far less slipshod field-work than some of our professed anthropologists have perpetrated in the past. On the other hand, local collectors in every part of the country should be encouraged to put their discoveries on record, even their isolated finds, and to examine all cuts and excavations in the old river terraces of their respective communities, because the accumulation of even isolated finds may ultimately pilot us to the long sought original deposits. As in Europe, the solution of the problem will depend upon the joint efforts of individuals residing in many localities and not upon the work of a single individual.

CHANGSHA AND THE CHINESE

By Dr. ALFRED C. REED
SAN FRANCISCO

PERHAPS to western eyes no feature of the seething life of the orient presents so strange and unexpected a contrast, so weird and startling an experience, as a first entrance into a Chinese walled city. China is to-day a land of contrasts, where the west and its civilization is sharply juxtaposed to the most ancient and conservative east. Like a wasp's nest a walled city from outside betrays no part of the swarming host within. A plain gray stone or brick wall alone is visible, so near the earth color that it is hardly to be separated from the other features of a monotonous brown landscape, were it not for the notched summit, an occasional gilded roof within, and the better view afforded where a chance hill may lift the wall into full perspective. In this latter case it stands out grim and suggestive of the age-long resistance of inertia, the colorless passive indifference of the race that fashioned it.

But this old Chinese wall has other qualities. Its fifteen to thirty feet of height and its solid ten to fifty foot width may represent the inertia and egotistic passivity of its makers, but they represent with equal truth those factors which have preserved the racial integrity of the Chinese and made them conquer their conquerors time and again through history, by extending apparent defeat into a slow process of absorption and assimilation. If the first view of the walled city reveals only the wall, and that in its somberest, most uninviting colors, so does the first contact with the race show only the instinctive racial opposition and contempt, the masking stolidity, indifference and hostility which surround like a grim gray wall the qualities of humanity, altruism and receptivity which are found in the Chinese at their best.

But now to leave the rich countryside, the broad winding river, the clumps of bamboos and camphor trees, the grave-covered brown hills, and the valleys and low places with their crowding paddy fields and vegetable patches—and to enter the tunnel-like runway with its massive iron gates which leads through the wall into the city. Once inside, a new world, strangely different from any other world, swallows up the spectator. The street is narrow, perhaps not over ten or twelve feet in width, and filled with a confused swarm of Chinese. No sidewalks, no horses, no carts, wagons, automobiles or street cars have any place here. Instead, coolies with baskets hanging from poles across their shoulders, wooden-wheeled barrows innocent of grease, rattling iron-tired rickshaws, an occasional sedan chair, multitudes of pedestrians, and underfoot dogs,

many pigs and children in all stages of dress and dirt—this fills the scene. Little sunlight penetrates the narrow crooked street, because from the one- and two-story buildings on either side, matting, thatch and bamboo awnings almost completely cover in the tunnel-like cañon. Then too the perpendicular hanging scrolls and cloths which replace the western advertising signs, help shut out the light.

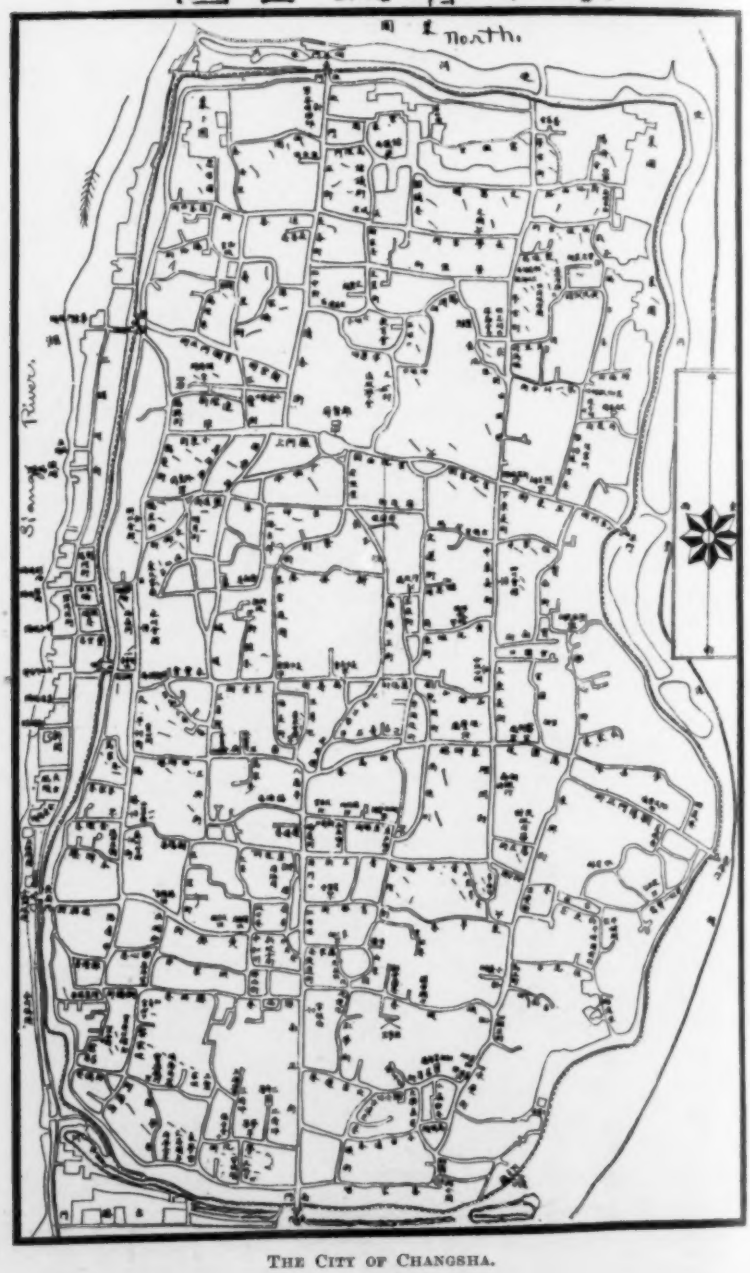
In such a scene does one find himself on entering Changsha through almost any one of its eight gates. Before going on to describe more minutely the strange drama of life within this great and wealthy old city, it may be well to orientate Changsha in place, time and interest. The geography of China has been recarved within the past few years. A glance at the accompanying sketch map will show that the eighteen provinces of China proper form a rough circle surrounded on the one side by the sea and on the other by the wild, desert-like, largely unexplored subsidiary territories of Manchuria, Mongolia, Sinkiang and Tibet. Looking again at the eighteen provinces, it is seen that the province of Hunan is but slightly south and east of the real center of China. The district of the eighteen provinces is divided into three parts by mountains extending in a general east and west direction, separating the valley of the Yang-tze river in the middle from the valley of the Hwangho to the north, and from the southern tier of provinces, Yunnan, Kwangsi, Kwangtung and Fukien, on the south. Hunan is thus not only near the geographical center of the provinces, but it lies in the central one of the three great physical divisions of China, and about midway in the course of the great Yang-tze through China.

The only approach to Hunan is through the valley of the great river, although the Peking-Canton railway, now under construction, will open a route directly south through the mountains to Canton. Hunan province, comprising a territory of 84,000 square miles, an area about equal to Kansas, has some 22 million people. Half of the province is occupied by the valley of the Siang river which flows into the Tung Ting lake in the north of Hunan, the largest lake in China. This river valley has extreme fertility and is densely populated. The upper half of it is tributary in trade to Siangtan, a city of 400,000 about thirty miles above Changsha. The head of navigation for the larger river steamers on the Siang is Changsha, 200 miles above Hankow. Except for the term of low water in January and February, large vessels can reach this point with ease the year around, and a regular daily passenger service is in operation between the two ports.

Hunan is a mining and agricultural province, but the mineral resources have been so far scarcely more than scratched. The mountains of the southern half contain enormous deposits of coal, chiefly bituminous, but with some anthracite, as well as abundant limestone, iron, copper, tin and antimony, and to a smaller extent lead, manganese and silver. The

Hunan antimony deposits are among the richest in the world. The Huachang Smelting Company in Changsha has a capacity of ten tons per day of this metal. The original plant of this company was imported from France and yielded but two tons a day, but the machinery was copied and enlarged in Changsha by native workmen to its present capacity. The establishment of two new antimony plants in Hunan is now under consideration.

Neither in mining nor in agricultural products, however, do the exports show a fair development, either in raw material, by-products or specialized products. Wood-oil, tea and groundnut oil, hemp, tobacco and rice, with a great variety of beans, are the chief crops for export. The province is a valuable source of timber, a commodity all too rare in



THE CITY OF CHANGSHA.

China where the short-sighted policy of indiscriminate deforestation causes the most disastrous floods the world knows. Even here no systematic reforesting is encouraged or practiced. Large rafts are made up at certain points on the Siang river where the pine, fir, laurel, camphor and other logs are collected from the various tributaries. These rafts, which are really floating villages, go down the river with the current, and the timber is distributed throughout the Yang-tze valley. The bamboo grows wild over the mountains of Hunan and is sent out of the province like other timber. Its smoky, feathery foliage, interspersed with an occasional camphor or palm tree, is one of the most beautiful sights observed. The bamboo shoots attain their maximum height in the first season and later years merely add to the thickness of the stalk. The bamboo in its first year rivals the banana in rapidity of growth.

Hunan produces a large cotton crop, especially in the northwestern section. The original seed came from America, but the stock has depreciated and the cotton is of very inferior quality. It can be bought in the street market for about ten cents gold per pound. Tobacco too is raised in large quantity, but its quality is poor. The Chinese is a prodigious smoker, at least in so far as pertains to the time spent on the habit. In Changsha the large, cumbersome water pipe is universal and indispensable for every class of society. A small wisp of tobacco shavings is placed in the bowl of the pipe, ignited with a fuse which is blown into a flame, and the smoke is inhaled at one or two puffs. The process is repeated ad infinitum. The pipe is passed around in every group of men, and women too, and each takes a whiff. For those exceptional ones who are too busy to manipulate their own pipes, a special public pipe with a long stem is available. This is carried about by a street vender, loaded with a wisp of tobacco, lighted, and the stem put into the mouth of the customer who takes his whiff without taking his eyes or attention from the matter in hand. A slender straight pipe is also used and cigarettes are increasingly frequent. The women and girls enjoy the pastime as much as the men, and in a land where everything is upside down or backwards, the custom seems neither strange nor unseemly.

The poor quality of cotton produced illustrates the entire ineptitude of the Chinese on his native heath or rather paddy field in introducing new or improved methods or agricultural products. Changsha is adapted in soil and climate for all sorts of citrus fruits, but the oranges are of the poorest, the best obtainable being imported, and foreign lemons are unknown. The native lemon is a large, coarse, slightly bitter fruit. Grape fruit are not found, but pomeloes are abundant and occasionally quite good. Even where good orange and lemon stock has been introduced, the farmers will not give proper care or learn better methods of production. The result is a rapid deterioration of imported stock and an extremely poor grade of native stock.

KULING MOUNTAIN, Summer Resort of Foreigners.

Of the rich and central province of Hunan, Changsha is the capital, lying in north latitude 28 degrees and 30 minutes, about even with Tampa, Florida, and 800 miles inland from Shanghai by river. It is the largest city of the province, having a population somewhere between three and five hundred thousand, and ranks among the oldest, wealthiest and best built cities of China. The Siang river gives it free communication by water with Hankow and thence by rail and water with Peking and Shanghai. The water life of China is among its most picturesque features, and the Changsha bund furnishes a kaleidoscopic review of the incoming and outgoing traffic. This city is fortunate above most Chinese cities in having near at hand very extensive quarries of excellent granite, which, cut in huge blocks, sixteen inches wide, six inches thick and from three to six feet long, supplies paving for the streets, building material for many of the more modern edifices and a lasting fabric for the sea-wall which protects the city and its bund from incursions of the river. This wall extends for three miles, averaging between twenty and forty feet in height and at frequent intervals having broad granite steps leading down to low-water level, so that, as the river rises, the boats merely come alongside a higher step. The large river steamers from Hankow and way-ports are docked alongside floating hulks which are anchored and chained in the deep water off the bund. From the hulk which acts as a landing stage, ticket office, freight depot and waiting room combined, a pontoon foot bridge leads ashore. These hulk-docks are characteristic features of the Yang tze steamer system.

Chinese river life is a world in itself, and the Changsha bund presents a never-ending and constantly changing panorama of water craft and river population. The great lumber rafts pass here, many a hun-

dred and two hundred yards in length, with their thousands of logs bound together with split bamboo withes, and surmounted by the thatched huts of the numerous crew and their more numerous families. The whole unwieldy mass of logs or bamboo is propelled in a variety of ways and at an infinitesimal speed. For time, like human life and labor, is of no account in China. Sometimes a long woven bamboo or hempen cable is stretched ashore ahead, and from twenty to fifty men pull. If the wind favors, a multitude of sails, large and small and of all colors, springs up in a variegated crop. Sometimes a huge sand anchor is fixed in the mud several hundred yards ahead and by means of a creaking wooden windlass, the raft is drawn up to it. Thus the rafts are taken up stream as well as down. There are also men and boys punting with bamboo poles, and innumerable sculls, working sampan-fashion, with often a half-dozen coolies swinging on one oar. The sampan oar is a curious affair and the Oriental method of rowing, the oarsman facing forward and standing erect, with short quick choppy strokes, is totally different from ours.

The Chinese houseboat is a commodious flat-bottomed structure with blunt ends, a high galleon-like stern, a tremendous sail-spread for a draught of but two or three feet, and it general style of architecture might well be descended from the time of Noah. Like all Chinese boats, the houseboat is provided with a pair of brightly painted eyes, else how could it see to make its leisurely way through the thronging fleet of river craft? In the junk and houseboat the steersman sits under an arching roof which covers in the stern and permits no vision to the sides or forward. He steers by land-marks astern and has an uninterrupted view of everything he has passed. This system works very well in the day time when other members of his crew or family are watching ahead, but at night it is not so successful and the situation is aggra-

TRAVELING IN THE COUNTRY MOUNTAIN CHAIRS, passing a paddy field.

vated by the entire absence of lights. Unlighted junks with only the steersman awake and no look-out ahead are the bane of the river steamers above Hankow and collisions are frequent.

Another feature of the water life is the cormorant fisher. This individual owns a sampan with a long fore and aft roost, on which are perched from five to twenty cormorants. Each bird has an iron ring around its throat which is just tight enough to keep it from swallowing a fish. The birds dive overboard, catch the fish and are hauled back with the prey in their mouths. Of other river industries, mention must be

TOMB AND SHRINE NEAR CHANGSHA

made of the duck farmers. It is no uncommon thing to see a solid mass of ducks, like a great raft, go quacking by, the column being held in shape and steered by a couple of sampans whose owners beat the water with long slender bamboo rods, and frighten the ducks into the straight and narrow path to market. Some of these flocks number from five to ten thousand birds, and so tightly are they wedged together that when an occasional duck is squeezed upon top of the main layer it must scramble to the edge of the flock to get its feet into the water again.

The Changsha city wall is about five miles in circuit and its broad summit provides barracks for many troops. The outer edge is raised into a granite and brick escarpment or parapet, from four to ten feet

higher than the level summit, through which numerous embrasures allowed the defenders to manipulate their artillery under protection from an enemy's fire. These old guns are dismantled now, but hundreds of them cast in various parts of Europe as well as China, are lying about, eaten with rust, and disregarded. Like most city walls, this one has an outer and an inner wall of brick or granite, and the intervening space of ten to eighty feet is filled with dirt. One old cannon is still mounted on the wooden trucks from which it helped defend the city against the Taipings. This is the gun which killed the Taiping general and a shed has been placed over it, together with an inscription telling why the people still worship it.

History states that Changsha was founded during the Han dynasty, one of the most glorious in Chinese annals, which flourished from 200 B.C. to about A.D. 200. The original wall has long since succumbed to

GRAVE-COVERED HILL AND A FARM HOUSE.

siege and assault, and there is little about the city except its graves to bear evident witness to its antiquity. It is almost unique in never having been pillaged or looted. As the capital and largest city of Hunan it attracts many of the wealthy class and the gentry, who select it as a desirable place of residence. Since being made a treaty port, the foreign community has steadily grown, until now there are over 200 Americans, British, Germans and other Europeans resident in the city or on the long sandy island lying in the river opposite. It is from the three-mile length of this island that the city takes its name, Changsha, or "long sand." On the island are the British Consulate and the residence of the commissioner of customs and other foreigners.

Great Britain, Germany and the United States maintain consulates in Changsha. The foreigners in the city are divided between the thirteen missions, seven German firms, five British, two Japanese, and one

AN EMBRASURE ON THE CITY WALL.

each American, Belgian and French. The American hong or business house is the Standard Oil Company branch, which is easily holding its own against its powerful oriental rivals. In 1913 a half of the total importation of kerosene was American, Changsha has a Chinese and a Japanese post-office.

Across the river from the city rises the beautiful wooded hill of Yolosan. With an altitude of but 800 feet above sea level at Shanghai, this mountain still gives a magnificent view over the hilly country on every side, and the river and city at its foot. On it is a large stone tablet, the Yu Pei, which recites the tale of the mastery of the vast floods which once inundated enormous sections of central China. This tablet was erected by the great Yu, founder of the Hsia dynasty, 2205 B. C. On the southern slope of Yolosan is a large high school, in which are Confucian and Buddhist temples. The mountain is heavily timbered from here to the Taoist temple on the summit.

Changsha is an educational center of importance. It boasts about thirty prominent schools, most of which are public and are maintained at least to a considerable degree by the government. It is to these schools that the people of the entire province look for an opportunity to study western civilization and methods. The Changsha educational system has an influence on 22 millions of people and is a controlling factor in their leadership and views. In this connection it is of course to be remembered that even in these so-called modern schools the old Chinese idea prevails, that the students and not the faculty are in control, and that a superficial smattering knowledge is too apt to replace genuine, thoroughgoing scholarship. These Chinese cares more for appearance, for a smooth and glittering surface, for an apparent acquaint-

ance with western learning, than he does for the genuine substrata that alone make possible the real western civilization. These traits appear just as prominently in the educational system as they do in the industries, the government and the ordinary every-day life of the people.

In Changsha are five normal schools, one called a high normal school and the others simply numbered from one to four. The latter prepare teachers for the primary schools, while the high normal fits them to teach in the middle schools. Board and tuition are provided free and the enrollment in each is about 400. In the high normal the average student age is twenty-two years; in the other four it is about nineteen.

The largest, and in popular estimation one of the best, of the middle schools is the Chang Tsuen, with an attendance of 1,200 students. Here too the tuition is free to Hunanese. Next in size are the Hunan Provincial Middle School and the Ming Teh School with 400 students each. The average age in these is sixteen years. The Higher Technical School of Hunan has an enrollment of 900, averaging twenty-one years of age. With lower requirements, are the middle and primary technical schools. In these are offered such courses as railroad and civil engineering, mining, architecture, chemistry and physics, and their laboratory equipment is fair. There are two commercial schools with 200 students each where business correspondence and book-keeping receive major emphasis.

The University of Hunan, with 400 students, makes a specialty of Chinese and foreign literature, politics and law. A railroad school, supported by the provincial government, has 600 students. There is too a school of communications, attended by a hundred boys, whose time is spent chiefly on the Tibetan and Mongolian languages. A police school, enrolling 500, prepares for positions on the police force.

ROOF SCENE, showing flat tiles and "Saitai" or roof platforms for drying clothes.

CHANGSHA BUND.

There are a dozen institutions giving instruction in politics and law, and they are well attended, for the Chinese ever has an impelling desire to become a public official and fatten off the land. A school of agriculture has 400 students, and in the future ought to be influential in improving this industry. Eight free primary public schools are maintained for both boys and girls. The average age in these is nine years and each school has about 250 pupils. Changsha has in addition about a dozen girls' schools with free tuition and each divided into three sections, normal, preparatory and primary. Chief emphasis is put on the study of Chinese and a counterpart in name at least of our own "domestic science" courses, the girls learning the various household arts and crafts.

Practical education is not an end in itself with the Chinese, but is merely auxiliary and always subsidiary to moral development. At least this is the attitude assumed in regard to it. But the educational system, like many other things Chinese, makes an imposing array on paper and in reports, while, judged by its efficiency and its output, it is a weak and inefficient institution. The old Chinese classical system has gone out, but so far the new learning has left only a surface mark and has in no sense filled the abyss left by the destruction of the old. The formulæ and the symbols are found, but the spirit and the scholarship have not yet taken root.

Life in the midst of a Chinese city offers many distractions to a mind bowed down with the weight of domestic woes and misunderstanding servants, the unbelievable difficulties of the currency or lack of currency, the unlearnable language, and all the multitude of vexations and torments which like a cloud of greedy mosquitoes, seek the fresh blood of the newcomer.[1]

[1] A. C. Reed, "New York to Changsha," *Pomona College Alumni Quarterly*, June, 1914.

Not contented with one coinage, the industrious Chinese has several kinds, in fact many kinds, and practically none are current beyond a more or less restricted district. Usually the Mexican silver dollar is good anywhere, unless it is filled with lead, or counterfeit, or "chopped," one of which conditions usually prevails. Each province issues dollars and they are variously discounted by other provinces. Another unit is called the tael, which is supposed to be a definite weight of silver, no coin being minted of this value, but even this standard varies from time to time and from place to place. The daily business of the people is conducted entirely in "cash." Paper cash exchange fluctuates widely, a dollar being worth from 1,300 to 1,800 paper cash. The paper cash and cash notes have been abolished in Changsha in favor of the copper cash. Each copper is worth ten cash, but the exchange rate again varies from 1,300 to 1,600 cash per dollar. A great obstacle to monetary reform in China is the banking and money exchange class, which makes a fat living off the exchange and is loath to see its profits disappear with a stable currency.

The Chinese language too is a topsy-turvy thing, differing radically in its construction and expression from anything western. Many years of hard study are necessary for a foreigner to gain a working knowledge of it. Chinese from neighboring localities are frequently entirely unintelligible to each other. The language is devoid of grammar, rule and reason: innocent of syntax and logic. It has a varying number of tones or inflections which are as essential in pronunciation as the word itself. The Hunanese are blessed with but five tones, but in Kwantung and Szechuen there are eleven. In Hunan there is a level high tone, a level low tone, a falling tone, a high and a low-pitched rising tone. To ignore tone is never to learn Chinese. The same word in a different tone has a totally different meaning. It is a language which children

A Temple Court.

AN AIRING IN THE CITY.

learn to speak easily, but which adults must study with the help of a musical scale.

When tone and syllable are correct there is the further matter of aspiration to be remembered. Whether to aspirate or not to aspirate is a question of equal importance with that of proper tone. Having learned several thousand words, all of which are monosyllabic and in Hunan ending with a vowel, there is the difficult subject of idiom to be mastered. On the proper arrangement of words in the sentence depends its intelligibility and often its meaning. Chinese idiom is a bug-bear few foreigners successfully overcome. For instance, having found the right words, and given them correct tone and aspiration, imagine an idiom which in order to say, "I am afraid the young gentlemen will not be pleased with me," says literally, "Apprehend fear young sir see not up I this piece man." Again for our generic word "thing," the Chinese says, "one piece east-west." If in desperation one falls into the horrors of "pigeon-English," still is to be remembered the remark of an applicant for the position of cook in a certain foreign family in which were seven ladies and one gentleman. The would-be cook on learning this astonishing fact, said in good pigeon-English, "One piecee he, seven piecee she, too muchee she, no can do."

Of the thirteen missions in Changsha, there is one which represents a unique and typically American movement, whose spirit and idea is engaging the interest and active support of a rapidly widening group of people. This is the Yale Mission, a movement founded and supported by an incorporated society of Yale alumni and faculty, and established on certain fundamental principles whose recognition in university circles is distinctly modern. These principles take account, on the one hand, of the critical need in China to-day of certain qualities and a type of men which Christian western civilization can produce, and, on the

other hand, there is due recognition of the unique opportunity of a great American university to supply this need in a most practical and statesmanlike manner. The movement gathers enthusiastic support from a widening circle of men and women of large philanthropy and missionary zeal in the broadest sense of the word.

Summer Costume, Temperature 110°.

Yale-in-China has no evangelistic activities. It is not entering on the field of the established missionary organizations. It is not in rivalry with the church movements. It is not isolated from the spirit of modern missions. It is, contrariwise, in most cordial agreement and sympathy with every activity seeking the moral, physical and spiritual betterment of the Chinese, and it has the cooperation and support of the established societies. It is not duplicating the work of others, nor crowding an old field of activity. It is entering a field previously untouched and giving to the Chinese of Hunan the best spirit, methods and Christian culture of the best type of American university, and giving to a growing number of American university men and women an opportunity for practical benevolence with no restriction of creed, dogma or self-interest. So attractive is the idea of this movement that it has already been copied in other universities and is forming a recognized form of modern social service and benevolence.

The work of Yale-in-China is two-fold, educational and medical. Or better, its work is purely educational, in two lines, academic and medical. In the ten years of its history to date, a carefully graded and fully staffed college preparatory department has been established, from which four classes have been graduated. The first freshman class in the college department entered in the fall of 1914. There are now 200 students and a faculty of eight Americans with a large staff of Chinese instructors. Practically all the instruction is given in English, except the first two years. An increasing interest is shown by the Yale boys in

MEDICAL STAFF AND GRADUATE NURSES OF YALE HOSPITAL.

things athletic, and under competent coaching they usually sweep the field in the interscholastic and provincial field-meets held in Changsha. A modern gymnasium is badly needed to supplement and facilitate the present courses in physical culture. The Chinese student is typically of defective physique, poor muscular development and with a strong predisposition to circulatory and pulmonary diseases. When given the opportunity, however, he takes as eagerly to athletic sports as his western brother of the American universities, and there is an immediate and corresponding improvement in his scholarship and his physique.

The Yale medical work comprises an extensive plant. Two hospitals are maintained, the Yale Hospital of 75 beds for women, and the Red Cross Hospital of 100 beds for men. Each hospital has a good clinical laboratory and operating equipment. At the Yale Hospital are the offices of the medical staff, the library, printing press and research laboratories. Each hospital has a modern pharmacy. The medical staff numbers six physicians and will be increased to ten within the near future. Two nurses' training schools are in operation under the supervision of two American graduate nurses. Regular instruction is given in both schools, for men and women, respectively, in practical and theoretical subjects.

At the initiative of the Chinese, arrangements have now been made for a definite contractual agreement between a Chinese corporation and Yale for the support of a modern medical college. The Chinese are furnishing land, school buildings, and money for operation, while Yale is to furnish the staff. Finally the China medical board of the Rocke-

feller Foundation has given the salaries of six new teachers in the medical college. This opens limitless possibilities and is the first co-operative movement of the sort to be instituted in China. The plan, moreover, has the hearty endorsement and support of the Peking government.

The Yale medical and educational work is temporarily housed in Chinese buildings in the center of Changsha. But within a year or two the entire plant will be moved to the fine new campus just outside the north gate of the city. The new buildings are now being erected there under the direction of an American architectural engineer. A new modern hospital of 120 beds, to be one of the best equipped in Asia, will adjoin the new Yale campus. The hospital will cost about $200,000 and will be especially fitted for the practice of modern medicine and surgery, for research and for teaching.

Changsha is coming to be a commercial center for Hunan. The development of export and import trade in central China is of very recent origin. Heretofore each province has imitated China as a whole in attempting to restrict buying and selling to purely domestic transactions. So there are still found inter-provincial customs barriers, and all too often, embargoes on the exportation of rice or other staples from one province to another. These feudal traits are rapidly disappearing as the country enters on its era of railroad building and as western men and methods become more influential.

Changsha manufactures in large quantity furniture, gold and silver articles, and coarse paper. Much pewter of varying grades of hardness is made from locally mined tin and lead. The ordinary grades have equal parts of tin and lead or two parts tin to one of lead. A

A Group of Children, patients in the Changsha Yale Hospital.

harder pewter is made by the addition of copper and antimony. Tin is extensively used for all manner of cooking utensils, water and oil cans, stove pipes and similar articles. Large quantities are also used for lining packing boxes and storage chests for summer, when it is necessary to protect against the dampness and heat, when mould covers shoes and gloves over night, and only the essentials are left out of the sealed tin-lined cases.

The first year of the republic was one of exceptional prosperity in Hunan and the general trade of Changsha improved correspondingly. For the year 1913, the Chinese customs report showed merchandise movements totalling taels 22,038,368, or about $306,088 United States gold. The increasing popularity of foreign-style houses was shown by a 50 per cent. increase in the importation of window glass. The copper supply is chiefly Hunanese in origin and comes to Changsha in the form of copper ingots to be worked up in the local mint into ten-cash pieces. Changsha exports may be divided into various groups. First among these come articles bought by foreign merchants for export abroad, such as ores and metals; white, yellow, green and broad beans; pig bristles; fresh eggs; feathers, hemp, hides, nut-galls; tea and wood oils; vegetable tallow and varnish. Second are articles exported by Chinese firms for domestic use, such as arsenic, bamboo shoots, black beans, coke-preserved eggs, fire crackers, grass-cloth, lard (to the Chinese in Straits Settlements), lotus nuts, medicines, nankeens, inferior paper, steel bars, tobacco and paper umbrellas. The third class includes articles bought by Chinese merchants for sale to foreign merchants in other lines, such as fire crackers, human hair, hemp, tea and tea stalks. A large proportion of the enormous production of fire crackers in Changsha finds its way through Canton to America for the Fourth of July.

Changsha has always been a hot-bed of rebellion and political unrest, but the purely local disturbances of the last five years probably owe much to Japanese instigation. The Japanese are throughout China and their influence is a constantly growing peril of the future. In June of 1913, Hunan declared its independence, but vigorous and effective measures taken by Governor Tang, a new appointee of President Yuan Shih-kai, and his 3,000 northern soldiers, very completely destroyed all illusions in the minds of the Hunanese as to their integral share, not only in the benefits, but also in the burdens of national and racial China. Governor Tang has had several years' residence and study in France and his acquaintance with western civilization makes him a strong factor in restraining the powerful reactionary element and in moderating the excessive zeal of the progressives of the half-assimilated western learning cult. In this as in most of China's political disorders, the common people have had little part and less interest. So near does the coolie or farmer live to actual starvation, and so tenuous is his margin

of safety, that he has neither thought nor interest for any affairs not connected with his daily toil for actual food. He cares not who rules, nor how well or wisely, unless his own little sphere of daily activity is jarred. When it is, there are disturbances of a widespread and iconoclastic nature.

Illustrative of this fact were the last riots which occurred in Changsha in the spring of 1910. The cause was not primarily an anti-foreign sentiment, but the lack of rice and the high prices to which the available supply was forced. The people blamed the governor for having permitted exportation of rice to other provinces, with good Chinese logic ignoring the inherent fallacy in the supposition that exportation of a staple article begets an unsatisfiable demand for it. As so easily happens with the conservative ignorance of this race, such an economic necessity immediately took the form of anti-foreign hostility. A demonstration against the governor's yamen thus turned almost naturally into genuine rioting at the mission compounds and the custom house. The Norwegian, Wesleyan and Catholic missions and the custom house were burned. The governor having fled, the lower provincial officers did not stop the rioting for two days. Foreigners were not attacked, but much property was destroyed, for which indemnity was later paid, the rioters never being punished.

To understand the Chinese character and to arrive at some reliable method for forecasting China's future, it is essential that several component factors be recognized. First and chief among these is the record and influence of the past. Nowhere do custom and precedent have such complete mastery as in China. The central element in Chinese life is reverence and obligation to ancestors. Indeed Maeterlinck's spirits of the dead would be constantly vivified in China, for the Chinese have them ever in mind. This sentiment is extended also to the ancestors' words and deeds. The critical weight of history and precedent in determining the reaction of the Chinese mind to a certain stimulus can not be exaggerated. The second factor is the condition of China in respect of religious beliefs. As Bland puts it,[2]

> There is the courage of an endurance almost superhuman in the lives of China's toiling millions, but the pathos and the poetry of a religion which redeems other Asiatic races from the heaviest penalties of materialism, have been sacrificed in Confucianism to the worship of genius, to an ethical system which contents itself with defining man's relation to man, and leaves him without enthusiasms, almost without curiosity, for the inner life and mysteries of worlds unseen. . . . The unity of the family and the state, the worship of ancestors, the three relations, and the paramount duty of labor,—these are the unshaken tenets of the Chinaman's creed, the sum and substance of his philosophy and religion.

The third factor embodies the present economic and sociological

[2] Bland, J. O. P., "Recent Events and Present Policies in China," p. 19.

condition of China. The overcrowding of population in cities is tremendous and everywhere the daily struggle for enough rice to last till the next day consumes all the energy and interest of the average man. The burden of Confucianism puts a premium on male children who will keep alive the parents' memory in their ancestor worship. Early marriages and an unbelievably high birth-rate play an unmeasured part in the physical inferiority so common. In this connection, it remains to be seen if improved sanitation, and measures for health conservation and for decreasing infant mortality, will in China be attended by a substantial reduction in the birth-rate.

The fourth factor is the kind of leaders China can produce in a crisis such as the present. The specific form of government which may be established is of minor importance. The great thing is the character of the men who control it. As always, character is everything and the particularized form of expression of ideas and ideals on paper is incidental. This latter failing for redundant verbiage and the recording of noble and altruistic sentiments of government and private living which have no connection with the actual practice of such excellent precepts, is a characteristic weakness of the Chinese. This is illustrated by an extract from a decree of the late Empress Dowager, Tz' Ann, given at Sianfu on January 28, 1901, after the sacking of Peking and the court's flight to Shensi, following the collapse of the Boxer movement.

> **The chief defect of our administration is undoubtedly too close an adherence to obsolete methods. The result is a surfeit of commonplace and inefficient officials, and a deplorable lack of men of real talent. Men of real ability are prevented from coming to the front by the mass of inefficiency which blocks the way. Our whole system of government has come to grief through corruption, and the first steps of progress in our empire are clogged by the fatal word "precedent." Up to the present the study of European methods has gone no further than a superficial knowledge of the language, literature and mechanical arts of the west, but it must be evident that these things are not the essentials upon which European civilization has been founded. China has hitherto been content to acquire the rudiments of European language or technicalities, while changing nothing of her ancient habits of inefficiency and deep-rooted corruption. Ignoring our real needs, we have so far taken from Europe nothing but externals.**[3]

These words apply to China with equal force to-day. Whether there are in the present time of change and unrest the seeds of permanent change and a genuine desire for thorough domestic housecleaning, time only can tell. China lacks leaders, men with "purposeful will-power," not self-appointed, but produced by the national emergency, and prepared by a life conforming to the very principles of honor and patriotism which Chinese writers so delight to extol on paper.

The fifth factor is the present relation of China to foreign powers, considering not only China's real attitude and desire toward them, but

[3] **Bland and Backhouse, "China under the Empress Dowager," pp. 422.**

also her obligations to them and the demands they may require of her. Space forbids discussion of this factor at present. To quote once more from Bland, whose words have prophetic truth,

> The Manchus have joined the great company of kings in exile and the Chinese people are left once again to work out their political salvation. The difficulties which confront them are intensified by the fact that no longer, as in the periodical anti-dynastic rebellions of the past, can they hope to reestablish the normal order by the light of their own devices and instinctive traditions. The world is too much with them. For good or evil China can no longer be a law unto herself. She has given hostages to fortune in the shape of European loans. Now and henceforth her crises and her civil wars are become matters of concern to the world-family of nations, her disorganization and unrest a source of danger beyond her borders.

China is indeed but now becoming aware that her age-long isolation is ended, that, irrespective of her inclination, she must assume an active part in the social fabric of nations, and that the sure penalty of failure is disintegration.

To-day China needs leaders and can not find them. She needs money, men and brains, but the greatest need is for men of character. The opinion is too common that China can do in a decade what required centuries in Europe. But history presents few real novelties, and China will not be regenerated or rejuvenated in a single generation.

THE MALTHUSIAN DOCTRINE AND WAR

By EDWIN W. JAMES

WASHINGTON, D. C.

THE habitual pessimist is deservedly without honor even in his own country. The occasional, though deliberate, pessimist, however, may be forgiven his unhappy temper of mind because in the times we live in he provides a pleasing contrast to the garish hues of thought that prevail. Our thoughts, like our garments and our conduct, are all tinted with the gay lights of an irresponsible optimism that can well endure an occasional dash of somberness if not too violently applied. Certainly the attainder of pessimism attaches to any one who reverts to the Malthusian theory in these days of sociological light-heartedness. It was Carlyle who, impressed by the theory of population advanced by Malthus, characterized political economy as "that dismal science." Thus did Malthusianism appear pessimistic even to the arch-pessimist.

Malthus produced the second edition of his essay in 1803, five years after its original appearance; and this second edition is considered the most complete statement of his theory. Though the essay ran to at least five editions, no essentials were either altered or elaborated that had to do with his theory of population.

For many years English economists very generally gave the doctrine much place in their discussions, though its principles were not pleasant in their application and led many writers to attack not only the theory, but even Malthus himself. These attacks became very bitter in some instances, but were principally supported by sentimentalism and left the essential basis of the doctrine unscathed. The worst that can be said of it is that, as applied by Malthus and more especially by such writers as Say, it produced for the proletariat a gloomy outlook that appeared at the time incapable of being dispelled.

That the theory of Malthus has in later years come quite generally to be disregarded is true. But it had its day, when for upwards of a generation it constituted a theme of persistent discussion. It reached very general acceptance and finally declined in the notice of economists. Yet its decline was rather a gentle sinking into desuetude, because of the very general and remote effects of its operation, than an abandonment because disproof was furnished of its truth or power. We find Say, Bowen, Mill, Walker, Marshall, Laughlin, Fisher and more especially other English economists, accepting the doctrine as originally stated, but some make no mention of it, considering it perhaps as unimportant now.

The Malthusian doctrine shorn of its appurtenances declares the inharmonious relation between the increase of population and the increase of subsistence, and attempts to establish a compatible relation by demonstrating a system of positive and preventive checks ever active and effective in creating a balance between population and the ordinary means of subsistence. Malthus reasoned that population tends to increase in a geometrical ratio. The greatest probable value of the terms of the progression were assumed to be a first term of two, a rate of two and an interval of twenty-five years between terms. This assumes that each pair will produce two offspring in twenty-five years. Opposite this possibility is set that of the greatest reasonable increase in agricultural produce. The law of diminishing returns and observations of agricultural conditions led to the conclusion that the limit of increase of food stuffs is an arithmetical ratio. As land can not possibly be increased, the inharmonious condition potential in these two laws can only be adjusted by checking the increase of population. Two classes of checks were enumerated and called, respectively, positive and preventive checks. Among positive checks were death from malnutrition or actual starvation, death from the unsanitary conditions of poverty, and, in general terms, famine, pestilence and war. Preventive checks were of a uniform sort, appropriately grouped under the single term moral restraint. Since the post-Napoleonic period, the force of moral restraint has grown amazingly, until its effect in occidental countries has been practically to annul all action of the positive checks. It is doubtless this general fact that has relegated the Malthusian doctrine to the economic shelf. A hundred years ago the preventive checks were undoubtedly assigned a much smaller value than what they have since developed. Under these circumstances, Malthus's contention that, unless preventive checks were made effective, the positive checks would act, led to the reproaches that were hurled at the dismal Malthusian who predicted hopeless death from starvation, and made political economy the object of the scornful description of Carlyle.

Now, the present state of Europe offers a field for interesting reflection in the light of the Malthusian theory. There is no purpose in this paper to defend any one nation or to justify the conduct of any. Certainly, on this side of the ocean, the first feeling toward the present conflict among sensible men was one of deep disgust that civilized nations could not find a method of settling international questions without resort to arms. But obviously if a single nation insists on such a mode of settlement, it precipitates the cataclysm of war. Nevertheless, however sensible men may have felt, that some nation should have resorted to the arbitrament of arms is not without explanation in view of the potential tendencies involved in the doctrine of Malthus. This paper concerns itself with pointing out an interesting relation between

the theory of population as demonstrated by Malthus and war as practised in our times.

Now, it has been stated by an eminent American economist that economic laws should be considered rather as tendencies, but as tendencies that will certainly become realities unless some other economic tendencies are set up or artificial conditions created to resist them. Even then the original tendency is potential, and becomes active the instant the restraint is removed. If, therefore, mankind has found the effect of the Malthusian theory apparently negligible, it is because something has happened to prevent the action of the positive checks. For under this definition of an economic law we may include the positive checks of the Malthusian theory. If, therefore, they have remained practically inoperative since shortly after the time of Malthus, it is because the preventive checks have been strong enough to restrain them. On examination, we find such to be the case. The forces that are inclusively designated moral restraint have in France, among the upper classes in England, among the native born in New England and, indeed, among the great upper-middle class of Americans, been so active that the increase in the number of births relative to the number of deaths has been reduced to a very small figure.

This fact indicates a force of moral restraint appearing in late marriages and small families, that surpasses any conception held by Malthus or his immediate followers. Indeed, moral restraint has developed and become so essential a part of the *modus vivendi* of mankind that among the various checks submitted by Malthus it overshadows all others. Moreover, the reduction of increase of population has been not merely against a death rate continuing uniform, but against a constantly decreasing death rate. While moral restraint has been holding back the births from an undue excess over deaths, many forces have been acting to reduce the deaths per thousand of population. With the advance of the last century, western civilization has become strongly characterized by a spirit of consideration for the rights of all men to an equality of opportunity. This spirit has operated in many lines. It has practically destroyed human slavery; it furnishes penny meals to underfed school children. Along with moral restraint have gone these other ameliorating influences. But while that has tended to lessen the increase of population, these have tended to augment the increase. These influences are now considered vital elements in our civilization. They are chiefly embraced in medical and sanitary science and in eleemosynary institutions. For sixty years the western civilized world has struggled against nature to reduce the death rate, and the efforts have been attended with a marked degree of success. The discoveries of Lister and Pasteur have revolutionized medicine, the germ theory of disease gave a tremendous power of control over contagion and infection, thereby over

epidemics and pestilence. Preventive medicine has done much to eliminate some of the worst plagues that were visited upon mankind for generations. The great heart of the century we have left was opened to the crying needs of the poor. Fiske and Kidd have shown how altruism came to combat the mercilessness of the survival of the fittest, so that the strong help the weak. Eleemosynary bodies of various kinds assist the lower strata of the population, help them to meet the pressure of daily needs, and literally keep many alive.

Now, it is to be noticed that all these ameliorating influences constitute modifications of the positive checks of the Malthusian theory. Famine is being driven from the door of poverty by individual and legislative assistance, as well as by advances in agricultural science. Infant mortality is being reduced by public agencies acting through a large sanitary organization. Pestilence among western nations is almost a thing of the past. Doubtless these modifications of the positive checks have been possible only because of the tremendous force of moral restraint. Had this been so slight as to have permitted occasional action of the positive checks, it is probable that human life would have been on so low and difficult a plane that little would have been done toward modifying them. But the general opinions of man among the western nations are turned now toward better conditions of living, toward better sanitation. The public mind is open to the precepts of preventive medicine and various alleviating restraints are accepted as matters of common good. The state, as well as individual charities, is devoting much attention to the improvement of the condition of the economic poor—those who have little or no capital, or who have but a narrow margin between them and mere subsistence. By all these conditions and measures the Malthusian positive checks have been and are being modified, with one rather startling exception.

While the western nations have been alleviating famine and removing pestilence, they have at the same time by every conceivable device of science been increasing the destructiveness of war. Since the development of the ironclad and the invention of the breech-loading rifle, both products of the civil war in America, the progress of military and naval science has been greater than at any other time in the history of the world. In at least two of the great western nations compulsory military service has existed for many years; in several others large standing armies and powerful navies have been maintained in times of peace. While the public mind has been turned toward ameliorating the harshness of famine and pestilence, it has been accustomed to consider war as a possible contingency, not to be combated as undesirable, but to be prepared for. The peace propaganda is very, very modern. This attitude constitutes an important difference. The preparations against famine do not serve to make the famine worse, should it come. Nor do the pre-

ventive measures taken to combat disease lead to increased malignity in pestilence. But the preparations for war, whether considered in the light of preventives or causes of it, do serve to increase its intensity and destructiveness of life when it comes. Further, this difference has its subtle reflection in men's minds. Should any one advocate the cessation of all the modern sanitary, medical and eleemosynary measures for the alleviation of the condition of mankind, the individual attitude would be unhesitatingly against it. Men are now accustomed to the restraints placed upon their conduct by sanitary laws and regulations, to the uses of preventive medicine, to maintaining some advisable forms of poor relief, to public hospitals and to the multitude of altruistic elements that not only enter into our western civilization, but are now an integral part of it, essential to its continued existence. On the other hand, their minds are filled by custom and familiarity with a tacit acceptance of war. They have paid taxes for armaments all their tax-paying lives. They see the army units and the fleet. At the seaside resorts and along coast and inland waters they know where fortifications are located and their children play on the ramps and slopes. In many countries they have served in the regular army during two or three of the best years of their young manhood. Some have attended military schools, some have been in the yeomanry or the militia. The individual mind finds no shock in considering a resort to war.

Assuming, now, that an economic pressure develops, what is the obvious result? The assumption disposes of the preventive checks, moral restraint and agricultural progress. Both have at last been found wanting. The positive checks being potential, being economic tendencies, and, therefore, certain to become realities unless counteracted, begin to operate. But they have been so modified that only one—war—remains in force. Man's mind, all western civilization, is used to a system of altruistic alterations of some checks, also used to the idea of war. Obviously, the human mind will not revert to pestilence and famine. It will rather tolerate the alternative of which the idea has already been accepted.

Resort to arms, then, is the only positive check left to meet and adjust economic pressure according to the Malthusian theory.

Let us briefly summarize our contention to this point. The Malthusian positive checks are economic tendencies. Of these, all but war have been modified for the alleviation of human misery, and these modifications have become an essential part of our civilization. In case of economic pressure developing, mankind will not yield these essentials of his civilization, but will resort to a method of relief for which his mind is prepared. War offers such relief, as the only positive check left, and war, then, is not merely a possibility in case of economic pressure, but is of the nature of an economic certainty.

Exactly what would be considered sufficient economic pressure to induce resort to belligerent measures is not a determinable matter. Instances are obviously not numerous enough for any one or any one general group to be fixed upon as distinctively causative. It is possible that pressure might be imagined that did not really exist. It is quite possible that, led by influential persons or governmental agencies, the public might assume economic pressure imminent, though not actually existing, and might consider this assumption of impending pressure as a sufficient reason for a resort to arms.

It must not be understood that the weighing of these matters is deliberate and conscious. It is no more so than those notions that, reproduced in a multitude of human minds, make effective the law of supply and demand. Where, as in the case of war, action is taken through national agencies instead of being merely cumulative, leaders propose, take irretraceable steps, and the populace generally acquiesces. This is particularly the case if there has been a general prevalence of opinion favorable to such action. It must be constantly borne in mind that no economic law acts like a chemical or physical law. Human agents are the medium through which economic tendencies act. Without the human intermediary economic cause produces no economic effect. Inasmuch as the human element is composed of a great number of units, the strength of opinion in any one need not be great in order to make the effect marked. Indeed, the attitude of any one individual need be no more pronounced than that of the casual housewife, who when marketing decides in the most colorless and matter-of-fact way whether or not she will buy the attractive vegetables displayed at a certain price. And yet, it is the accumulation of such casual decisions that make operative the law of supply and demand with respect to a great mass of commodities. The necessary conditions are similar for a belligerent national attitude. Where, in addition to the cumulative effect of public opinion, there exist leaders capable of augmenting the apparent force of such opinion, who indeed may actually make it appear other than it really is, the chances of a very slight mental inclination on the part of the individual may, by its cumulative force, produce tremendous results. The effect of leadership on such slight individual opinion, when it contains any elements by virtue of which it can be organized or led, is seen in a small way in the effect of consumers' leagues and associations of women who have forced dealers in some of our larger cities to lower prices within a few hours on certain perishable commodities which were offered at unwarranted prices. So great is this cumulative effect, that the very slightest guidance of the most casual public opinion into a single economic channel produces a flood.

Obviously, there exists the greatest possible danger that this force of opinion will be misled, will be directed by demagogues into wrong

channels. This danger has always been recognized and is doubtless very real. It is certainly no less true that opinion properly led and directed will produce just as effective results as when diverted from its natural course or distorted from its natural form. Indeed, it might be reasonably supposed that such opinion would produce more effective and lasting results if properly guided, because it is then free from the impeding force that change of direction would involve.

It is not, therefore, necessary that some specific type or extent of economic pressure be discovered to establish the general truth of the connection between the Malthusian doctrine and modern war. That such pressure exists at any given time will be shown by the state of the individual mind in a degree no more pronounced than that state of mind which enables demand to act upon supply. It is only necessary that that state of the individual mind be sufficiently general to have a belligerent effect. The result will be war at the first opportunity; and the opportunity will probably be made.

That there should occur sufficient economic pressure to produce belligerent action is in no way out of harmony with the past effective operation of preventive checks. It is a fact that Malthus and his contemporaries for many years did not assign to moral restraint the great effect it developed in the last half of the nineteenth century. Nor did they allow for such advance in the agricultural arts as modern scientific farming has produced. These advances may well be associated with moral restraint in bringing about an adjustment between subsistence and increased population. One has caused the increase to be slower, the other has provided for subsistence for the increase beyond the point where the pressure of want would otherwise have been felt. The combined action of these forces has served to raise the numerical level of population and maintain it free from actual want. The effect has been to postpone action of the positive checks; but it can not properly be said to have destroyed them. As previously pointed out, the positive checks are to be accounted economic forces and as such are potentially active at all times. If restraining forces have raised the zone of economic pressure or altered its type, it has only been like raising the levees as the floods rise. The distance between gauge height and the top of the levee has remained constant, and the action necessary to produce pressure of a dangerous sort may be no greater to-day than it was a century ago. The powerful and sustained action of preventive checks over a long period has created an economic structure and maintained it in equilibrium at a much higher level than would otherwise have been possible. Should such preventive forces cease to act, for this very reason the collapse would be more violent. Population would at once be subject to accumulated pressure temporarily held in check. One can hardly imagine the effects should all moral restraint, all the improvements in

agricultural science during the last sixty years, be suddenly eliminated. Those earning but a living wage to-day, those having no, or only a slight, margin above mere subsistence, would face actual starvation within a single agricultural season. Within that time the cost of staple foods would rise to a point far beyond the reach of a great mass of the population of many countries.

It must be borne in mind, then, that preventive checks serve only to postpone the time of effective economic pressure. They do not eliminate it or even postpone it indefinitely. Like the levees referred to, raised against an encroaching stream, in time the ever increasing floods will rise above them unless they too are raised up higher. Any given set of preventive checks serves only for a period. Their effectiveness must increase *pari passu* with the increase of population permitted by them. If they fail to increase, they fail to continue preventive. The length of the period of restraint does not alter the principle, although it may obviously alter the method by which the principle will act if it is permitted to by the removal of restraints.

Although the degree of economic pressure is indeterminable that will produce a resort to arms, there appears no reason why the necessary pressure should not occur. Moreover, the economic field in which such pressure may arise is much more extended than in the days of Malthus. He supposed the pressure of subsistence to be the only one, or at least the most active one. But to-day we have several other directions in which pressure may more likely be developed.

For it is to be noted that modifications of the positive checks, tending to increase population, and the action of moral restraint, tending to decrease it, along with the advance of agricultural science, permitting some increase without additional pressure, have all operated together to raise the standard of living. This means nothing, unless it means that those things which were once luxuries have generally, in different measure among different groups of mankind, but throughout all contiguous groups existing at any given time, altered their classification and become necessaries of life. Once we pass from the merest elements of food and clothing, and from such a modicum of shelter as mankind can survive with, the line between what is a necessary for life and what a luxury becomes a matter of custom and habitude. The result of this elevation of the standard of living is to establish large groups of the population with an ample margin above mere subsistence, and to provide some margin for all groups existing at any given time, except that new group, provided for by the numerical increase of population, which is alike the newest and the lowest. This group may be assumed to exist only slightly above the margin of subsistence for at least a short time. A concomitant result of the change in the standard of living is to provide, in addition to the pressure of mere subsistence, a multitude of

points of contact between groups, or between nations, capable of responding to economic pressure. Communication is the necessary and sufficient element which at once unites nations and furnishes the numerous avenues along which this pressure may act.

These numerous points of contact may be assembled under a few simple heads; such as commercial, political, and the unequal distribution of world wealth. This latter may be called economic advantage or natural advantage.

If we assume any nation to be existing in such a status as to be free from all pressure, it follows that the industries of the nation as a whole enjoy unrestrained development and prosperity. For in such an assumption, no foreign competition could exist. Similarly, we may assume that pressure is such as to permit the unrestrained and unusual development of a few or even of a single industry or even of an exclusive phase of some large and important industry. Under these conditions, habits of living are acquired by the nation as a whole or the group within the nation, depending on the successful industries, which fixes more or less certainly its economic position with relation to other nations. Suppose now, that another group, as another nation, invades the particular commercial field so far as to produce pressure on the first group hitherto enjoying freedom from pressure. It is felt through the usual channels of competition. The depression of the industry affected does not bring the corresponding group face to face with famine. But it does tend to lower for them the standard of living. It brings pressure on their standard of comfort. This is just as truly economic pressure as that of want produced by lack of subsistence. If unresisted, its effects will not be so fatal; but man's disposition to remain passive under it is no greater than his willingness to accept hunger in even a slight degree. Indeed, man's disposition and powers are such that his actual resistance to such pressure will be greater than it would be were his strength only that predicated by mere existence on the verge of starvation. Being stronger, he resists more vigorously. The group concerned, then, having enjoyed certain privileges flowing from the elevated standard of living, are able to make their cry heard. Were this group on the edge of mere subsistence, though economic pressure would then be absolutely a more serious matter, they would probably have neither the ambition, the means nor the time, in their struggle for mere existence, to make themselves heard.

Thus it is that those newly exposed points of contact, classified as commercial, may produce much greater results with much less pressure than would at first thought be expected. When the groups are nations, as suggested above, then the commercial pressure is a matter of considerable moment to some more or less small class of leaders. These, by association of interests, can use their influence to exaggerate the

actual pressure until it is made to appear as an impending national calamity. How great such influence can really become within any nation may be seen in the tariff history of the United States. If this pressure becomes sufficient, or can be made to appear sufficient, the leaders can act, take irretraceable steps, and the public is very likely to acquiesce. This sets into operation the only remaining positive check in hopes that the pressure will be removed.

Then, there may arise conditions in which the points of contact between nations, capable of responding to pressure, may be classified as political. Such pressure was felt and strongly developed during the French Revolution and during the decade centered about 1848. Europe arose against the French Revolutionists because Monarchy feared the pressure of Republicanism. The disturbances all over Europe during 1848 can be traced directly to the pressure produced on Absolutism by Republicanism. This form of pressure, as it obviously lends itself to exaggeration and distortion more completely than any other, is the most difficult to isolate and free from accessory and complicating conditions; but it appears most probable that such pressure or seeming pressure was made use of to provide cause for the existing conflict in Europe.

The decline of the absolute power of western monarchs has not served to remove possibility of pressure on the political points of contact among nations, so long as the monarchical institution is maintained with stratifications among the population. The "king's friends," the monarchical party or class, will always remain most sensitive to such politico-economic pressure, both actual and mediate. Being, too, of great influence, these individuals are strongly inclined to exaggerate the pressure for their own ends. The position, the influence, the advantages of certain privileges accorded to artificial rank, the emoluments and sometimes the estates of such persons are held subject largely to the continued existence of monarchy. The positive check of war, expected to remove the pressure, is brought into operation quite easily so far as this class is concerned, for individually their opinions are more generally and more strongly inclined toward war than those of any other class. With them it is largely a matter of tradition, a survival of feudalism, a tattered remnant of chivalry. It remains only to impress the fact and the degree of such pressure upon the other classes of the nation. The monarchical tradition has always been strong among the nations of the world until actual collapse of the kingly power has come, so such necessary impression is more easily conveyed than might be supposed. This arises also from the fact that the control of the governmental machinery, of the entire national regime, is almost wholly in the hands of the monarchical element wherever it exists.

Finally, there is a third series of points on which nations come into contact capable of transmitting economic pressure. These points are

established by natural advantages, or other causes producing an unequal distribution of world wealth. The fortunate geographical position of one nation gives it advantages, such as reside in sea-ports, in fertile plains, in navigable rivers, that another nation may not possess. Again great mineral wealth and other natural resources of tremendous value may accrue to one nation by the merest chance of locality. Obviously such natural vantages give the possessor a stronger economic position than that of another nation less fortunately supplied. This unequal distribution of the wealth of the world may develop an economic pressure. The less fortunate nations have to strive harder to create compensating advantages by industry, thrift and self-denial. As these virtues remain ever necessary, and serve only temporarily to decrease the gap created by unequal distribution in a large way of worldly advantages, the impelling force, acting on the nation, to produce bodily comforts, ease and wealth assumes at last the aspect of economic pressure. The nation labors under a natural disadvantage. If other nations labor equally, the natural disadvantage is never overcome and the gap, though perhaps never widening, remains and perpetually represents an enormous quantity of wealth, and its accompanying ease and enjoyment, that is denied to the nation by mere chance. This, at least, is how it appears to the minds of the group so affected. We hear it said, for instance, that they want "a place in the sun." War then plays the rôle indicated for it, and resort is had to war in the hope that the pressure of disadvantages will be removed by the fortunes of war.

It is of course possible that a combination of these various forms of economic pressure, together with that of subsistence, may arise. The last two forms are particularly likely to occur in juxtaposition, and it would seem, for reasons already cited, that a monarchical party could be particularly successful in augmenting the sense of pressure which flows from the unequal distribution of worldly advantages. Such appears to have been the case in the present war.

Summarizing again, we find that the degree of economic pressure to produce a resort to war is not determinable. This fact does not alter the status of war as the only effective positive check remaining. The germ of economic pressure resides in the public state of mind and need not be strong in any individual. That such pressure exists is not inharmonious with the past action of preventive checks. There are forms of economic pressure other than that of subsistence, possible and probable under the conditions of modern civilization. Pressure may have a commercial or a political basis or may rest on an unequal distribution of natural advantages. In any case of economic pressure the public mind is prepared by custom, teaching and general familiarity, to accept war as the only possible check. War, then, tends to follow not only the pressure of population on subsistence, but also pressure on the standard

of living flowing from commercial causes, pressure on the type and stability of government flowing from foreign political conditions, and pressure on the general mode and circumstances of the national regimen flowing from an unequal distribution of the natural advantages of the world.

The contention thus developed leaves us in much the position that might be expected to result from any reversion to the Malthusian doctrine. Pessimism is of the essence of the conclusion. And, yet, as in the case of the earlier Malthusian developments, the conditions may not be so hopeless as they at first appear. Just as an unexpected opposition to the free activities of the original Malthusian positive checks was found in moral restraint, so a relief from an inevitable belligerency among the nations of the world may be found in an enlightened attitude toward international relations. A mere propaganda in favor of peace will not suffice. This would doubtless serve to alter the opinions of some, perhaps of many, but it must make its way constantly against the established opinion of mankind and in direct opposition to definite economic tendencies. To secure itself, therefore, in a position of strength and influence, such a propaganda must not confine itself to the advocacy of peace for the sake of peace, because as matters stand now war may be made for the sake of better things than peace in the mind of the world. It must aim directly and intelligently at removing the causes of possible pressure. Government must make lawful the dissemination of knowledge of contraceptives to assist moral restraint, agricultural science and rural development must be advanced and improved. Rural life must be made attractive. Free trade among all nations must be furthered. Every possible hindrance to trade must be removed, tariff and trade wars must be entirely abandoned and nations must be taught to develop their own peculiar advantages if any exist, and exchange the products through the customary channels of international trade for the products of unusual advantages possessed by other nations. Republican government must be made more efficient and absolutism in all its ramifications discredited and finally abolished all over the world.

Unless such results flow from a peace propaganda, it is effort wasted. Only in the degree that these conditions obtain will the possibilities of war be removed, and until the causes of economic pressure are eliminated or equivalently controlled, belligerency remains a potential economic force, for which men's minds are prepared; one without existing alternative, ever impending, ready to become active as the result of indeterminable, but probably slight economic pressure.

ON THE REPRESENTATION OF LARGE NUMBERS AND INFINITE PROCESSES

By Professor ARNOLD EMCH

UNIVERSITY OF ILLINOIS

IN a popular sense large numbers often cause amazement, or command respect and arouse curiosity. Sometimes, when occurring in problems of chance, they assure practical certainty, or reveal the law according to which an event may be repeated. From extremely large numbers we may pass to infinite numbers by defining these as numbers that are larger than any finite numbers. Although infinite numbers are no proper numbers at all and can not be explicitly represented or conceived, it is in many cases possible to state or establish the law of their formation, and to use them in the deduction of important results. In fact, they are of the greatest importance from a mathematical standpoint. The same is true of infinitely small numbers, the reciprocals of the infinitely large. Very small causes may have tremendous effects. But it is nevertheless true that, while theoretically the infinitely small is just as important as the infinitely large, it is the colossal, the enormity of a number, of a quantity, of a magnitude that appeals to the popular imagination. The distance of a thousand light years which light travels in a thousand years is, for example, of such a character. All astronomical distances, no matter how large, as long as they are defined by a finite number of light years, are finite and can be expressed by a finite number of miles. The infinitely small and large, on the other hand, are antinomies which can be approached through indefinitely increasing and decreasing finite numbers only; they are concepts which are imposed upon the human mind (Zwangsvorstellung) in the form of postulates. Throughout the history of human thought attempts have been made to explain the mystery of the infinite. In ancient times, sophistic and mystic methods, partly connected with the supernatural, were ordinarily followed to explain the secret. The well-known problem of Zeno is a typical example of the reasoning that was applied in case of an infinite process. The Eleat Zeno (born about 500 B.C.) contended that such things as multiplicity and motion were impossible. To prove that there can be no motion, Zeno devises the problem of Achilleus. In a race between the fast runner Achilleus and the slow moving tortoise, the latter can never be reached by Achilleus, because the pursuer must always first reach the point where the pursued was. During this time-interval, the tortoise gains headway and

reaches a point ahead of the pursuer. Thus, during each successive time-interval the tortoise moves some distance ahead of Achilleus, and as the number of intervals increases indefinitely, the race can never end. This, according to Zeno, proves the non-reality of motion. The sophistry of this reasoning is, of course, apparent, although there are some modern logicians who are inclined to side with Zeno.

Even much later as great a philosopher and mathematician as Leibniz (1646–1716) mixed up metaphysical speculations with the discussion of mathematical infinity. Leibniz discovered the diadic system, according to which every number may be represented by a definite succession of the two ciphers 0 and 1 only. He identified 1 = unity with God and 0 with nothing. God created all things out of nothing, just as all integral numbers may be formed by the ciphers 0 and 1 in the diadic system. Leibniz was so enthusiastic over this seemingly remarkable discovery that he asked the Jesuite Grimaldi, at that time president of the mathematical tribunal of China, to communicate the discovery to the Emperor of China, who had the reputation of being a friend and patron of science. Leibniz hoped that in this manner the Chinese Emperor might be won over to Christianity.[1]

In a letter[2] to Christian Wolff, Leibniz discusses the infinite series

$$1 + x + x^2 + x^3 + \cdots,$$

which is obtained by dividing unity by $1 - x$. When x is less than 1, there is no trouble, the value of the series is equal to that of the quotient $1/1 - x$. For $x = -1$ the value of the quotient is $\frac{1}{2}$, while the series assumes the form

$$1 - 1 + 1 - 1 + 1 - 1 + \cdots \text{ad infinitum.}$$

In this case, the infinite process in forming the series is devoid of any meaning; the whole argument breaks down. This is not what Leibniz and other contemporaries thought. He reasoned as follows: The series is infinite; when we take an even number of terms their sum is zero; for an odd number the sum is unity. Now, as we can not distinguish between an even and an odd infinite number of terms, the total number can be neither even nor odd, and the sum of all terms can therefore be obtained in the most natural manner by taking the average of the two values 0 and 1. This, according to Leibniz, gives the sum of $\frac{1}{2}$ for the infinite series. Leibniz refers to another Italian Jesuite, Grandi, who saw in this example the proof of creation as revealed in the Scriptures. Adding the terms of the series in groups of two, $(1 - 1) + (1 - 1) + (1 - 1) + \cdots$, we get

$$0 + 0 + 0 + \cdots \text{ad infinitum} = \tfrac{1}{2},$$

[1] La Place, "Théorie analytique des probabilités," Oeuvres, Vol. VII., pp. cxviii–cxix (1812).

[2] "Leibnizens mathematische Schriften," Erste Abteilung, Band IV., pp. 382–387 (Halle, 1850).

which, according to Grandi, proves the divine power to create something out of nothing. Laplace, commenting upon the fallacy of Leibniz' arguments, shows that there is nothing particular in the foregoing series, since the expansion of the quotient $(1+x)/(1+x+x^2)$ gives the same series, while its value for $x=1$ is two thirds.

The controversies on the infinite have lasted to the present day. It must be admitted, however, that they have assumed in most cases a very refined and exquisitely subtile form. In certain respects the difficulties have increased, and arguments in the style of Leibniz and his contemporaries appear as infantile efforts of a vanished period. The logicians have come to discuss the possibility of such concepts as "the class of all classes" and other artificial difficulties. Sometimes it would seem that the modern logicians are again occupying the stage vacated by the Greek school of Sophists centuries ago. It can not be said that they have come nearer the solution of the riddles of the universe.

Probably the greatest advance in the concept of infinity has been made by the definition that an aggregate of elements is infinite when the number of elements of a part of the aggregate is the same as the number of all elements of the aggregate. A popular expression for this definition may be put in the form: Infinity has the property that a part is equal to the whole. Consider, for example, the series of all positive integers and multiply each by two, then we obtain a second series of integers that contains exactly as many integers as the first series:

1	2	3	4	5	....
2	4	6	8	10	....

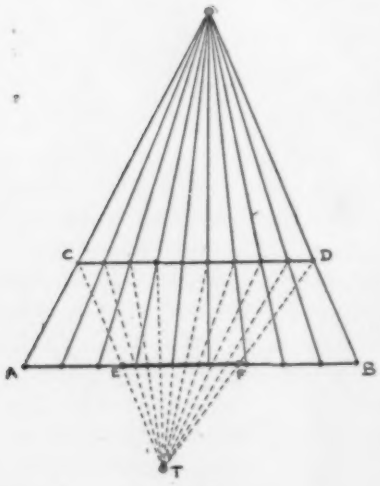


FIG. 1

The second series, however, is evidently contained in the first. The same definition applies to continuous sets of points which after the method of Dedekind may be put into one-to-one correspondence with a continuous set of real numbers. Let AB, Fig. 1, be a segment of a straight line and consider the infinite number of all points of this segment, including A and B. From a point S project the points of AB upon the segment CD, so that in this correspondence there are as many points on CD as there are on AB. From another point T, we can project the points of CD upon the seg-

ment EF which lies on the same straight line as AB, such that AB contains EF as a part. Now there are as many points on EF as on CD in the projective correspondence, and consequently as many as on AB. In other words, the number of points on AB is the same as the number of a part of AB.

Pure logic, detached entirely from intuition, is impotent in the treatment of such problems. It is not only sterile, but engenders new antinomies.[2]

As has been stated before, there is no difficulty in the investigation of large numbers as long as they remain finite. Although the answers to problems which involve very large finite numbers may be amazing, they are definite and, at least theoretically, may be made intelligible through proper representation. It is evident that in concrete form a large number does not necessarily have to be connected with large spatial dimensions. Thus, in the relatively small space of one cubic centimeter of air under standard conditions, there are thirty million million millions of molecules. On the other hand, the distance of the nearest star (α centauri) is four and three tenths light years, or about twenty-five million million miles. There are telescopic stars whose distances are measured by thousands of light years. Light travels 186,330 miles a second and it would take the light of those stars thousands of years to reach the earth. To the scientific mind the revelations of astronomy are not more wonderful than those of the ultramicroscopic world. As an example we mention the remarkable molecular structure of crystals, as shown by Professor von Laue, who recently received the Nobel prize in physics for his discoveries. The wonderful geometric lattice-work formed by millions of molecules per cubic millimeter is revealed on the photographic plate by the diffraction of Röntgen rays on the molecules. Here we have the counterpart of the extremely large. The wave-length of Röntgen rays is so extremely small that they are diffracted by the extremely small molecules of the crystal. These may be considered as extremely small models of solar systems in which the electrons take the place of planets and other heavenly bodies.

Just as it is convenient to make use of auxiliary units like the astronomical unit (distance of sun from earth = 93 million miles) and the stellar unit (light year), great numbers in entirely different domains may be made more intelligible by concrete representation. Take, for example, the arithmetical expression 9^{9^9} which means nine raised to a power whose exponent is nine raised to the ninth power. The number thus obtained is certainly finite, although its explicit representation would be well-nigh an impossible task. For practical purposes, and in

[2] Poincaré, "Science et Méthode," pp. 210–214 (1908). See also "Les étapes de la philosophie mathématique," by Léon Brunschweig, pp. 370–393 (1912), where an excellent discussion of the logistic philosophy of mathematics is given.

the language of the layman, we might call this number infinite. It has 369 millions 690,000 places. To write it down, reserving one fourth of an inch for each cipher, it would take a strip of paper that would reach from Phoenix, Arizona, to New York City. Compared with this, the number of atoms in the Atlantic ocean would be negligibly small, and the Hindu fabulist with his story of a battle of a sextillion (unity with 36 ciphers annexed) monkeys would not strain our imagination as to largeness.

Large numbers, relatively small in comparison with those given above, are of great practical value in the theory of probabilities and statistics. By mathematical probability of an event we understand the ratio between the number of cases of actual occurrences and the total number of possible cases of the event. The greater the number of actual occurrences out of the total number, the larger the probability of such an event. When the two numbers are equal then the probability is equal to unity, in other words, the probable event becomes certain. A larger number of repetitions of a certain type of events contributes to our judgment of certainty. This fact has been stated by Poisson as "the law of large numbers," and may be expressed more definitely as follows: If p (a proper fraction) is the constant probability of an event and if the conditions for this event are repeated s times, whereby it occurs actually m times, then, by repeating the conditions a sufficiently large number of times, the difference between p and s/m can be made as small as we please. Thus, the probability that in the game of throwing a coin, head will appear is one half. Buffon, who once had the patience to do this 4,040 times, obtained 2,048 times head, so that the difference $p - s/m$ is in this case -0.007. If Buffon had repeated the experiment a million times the difference would be very much smaller. The fact that during the last 6,000 years, days and nights have followed each other without a break over two million times makes it certain that the sun will rise in a clear sky or behind a cloud to-morrow. From the standpoint of mathematical probability and large numbers there is nothing extraordinary in two million confirmations of an event. And yet, in every-day life, such numbers in the realm of chance mean certainty to us. Mathematically speaking, we are satisfied with very crude approximations in this world. We never use anything else in practical life than comparatively very simple rational numbers. For $\pi = 3.1415926\ldots$, with an infinite number of ciphers, we never can use anything else than a rational approximation. Although the ten thousandth place of this transcendental number is an absolutely definite cipher between 0 and 9 (inclusive) we do not know what it is and it is a physically impossible task to determine it. We live in a domain of relatively small rational numbers and are satisfied with crude approximations where absolute accuracy can not be obtained.

Pure mathematical reasoning has nothing to do with the world of approximations. The number π has an absolutely definite meaning and exists. Likewise the incredibly large number defined as nine raised to the power (nine to the ninth power) is absolutely definite and finite in spite of the explosive character of its increase. The infinite series

$$\tfrac{1}{2} + \tfrac{1}{3} + \tfrac{1}{4} + \tfrac{1}{5} + \cdots \text{ad infinitum}$$

for which the sum of an increasing finite number of terms creeps along with unbelievable slowness, is divergent, *i. e.*, it has an infinite value. Indeed, when we add its terms successively in groups of one, two, four, eight, etc., we obtain an infinite number of such groups whose values are all larger than $\frac{1}{2}$, so that the value of the series itself is infinite. The problem shows an entirely different face when we attempt to actually add up the fractions in order to see how they contribute to the infinite value of the series. From the standpoint of the computer the legitimate mathematical claim for divergency of the series appears as a ridiculous pretense. Let us, for curiosity, figure out how many consecutive fractions of the series one must add to each other in order that their sum will amount to 100. Suppose that it is possible to write these fractions upon a strip of paper one half inch wide so that a cipher is reckoned for every half inch of length. With this strip the whole universe for which we assume a diameter of about 20,000 light years could be completely wrapped up and covered to a thickness of hundreds of miles. Millions of tons of ordinary writing paper would be necessary to manufacture such a strip of paper. This much is necessary to make a contribution of about one hundred units to the infinite account claimed by impeccable mathematical logic. In spite of practical impossibilities of this kind, there is of course no sound reason to dispute or criticize the rigorous conclusions of science as has been done in a very clever essay by Alexander Moszkowsky in "Zukunft."[4]

In conclusion, I shall briefly discuss a geometrical example involving an infinite process with a perfectly definite result. A complete geometrical representation of the process is impossible. But this is not more remarkable than the impossibility of making a visible representation of an actual mathematical point, or of a circle. In ancient times the possibility of a tangent was always connected with the idea of a continuous curve. Since the classic discovery of Weierstrass of continuous functions without derivatives, that idea had to be completely abandoned. As Peano and others have done, it is easy to state perfectly definite laws for the construction of continuous curves that admit of no definite tangents. To construct such a curve consider, for example, an equilateral triangle whose sides are equal to the unit of length, Fig. 2. Divide each side into three equal parts, remove the middle parts and

[4] "Das Geheimniss der grossen Zahl," Vol. 78, pp. 85–94 (1912).

bridge the gap over by two adjacent pieces, each of one third the length of the original side. In this manner a new Fig. 3 is obtained whose circumference is evidently four thirds of the original length of three units. We now repeat the same operation on each of the twelve segments of the new figure and thus obtain Fig. 4, whose circumference is four thirds of that of Fig. 3, *i. e.*, $(\frac{4}{3})^2 \cdot 3$. We repeat this process a third (Fig. 5), fourth time, and so forth, *ad infinitum*. The circumference of each new figure is always four thirds of that of the previous figure. Repeating the process n times, we obtain a crinkly curve with the length $(\frac{4}{3})^n \cdot 3$. When we let n approach infinity, the figure approaches a perfectly definite continuous curve of finite dimensions, but of infinite length, since the nth power of $\frac{4}{3}$ increases indefinitely as n increases indefinitely. This curve defined by a very simple geometric law is a so-called Jordan-curve and has H. v. Koch and Cesaro as its originators.[5] A complete geometric construction of this curve, involving the configuration of the limit, is impossible.

FIG. 2

FIG. 3

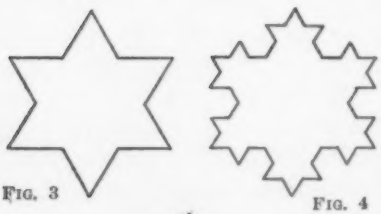
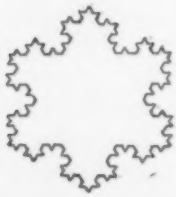


FIG. 4

FIG. 5



As is shown by this and other examples, we can conceive in a perfectly definite mathematical sense infinite processes which do not admit of complete explicit representation. This, however, is not more remarkable than the impossibility of representing explicitly all elements of certain extremely large finite and transcendental numbers.

Insurmountable difficulties only appear when we try to grasp problems involving the infinite by introducing peculiar logistic postulates. Then paradoxes and antinomies become supreme.

[5] E. Study, "Konforme Abbildungen," pp. 42–43 (1913).

THE ENERGY CONTENT OF THE DIET[1]

PROTEINS IN GROWTH

By RUTH WHEELER

UNIVERSITY OF ILLINOIS, URBANA, ILL.

AN eminent biochemist said recently to a friend of mine: "The time is coming when you will give a grocery order in this fashion: 'Send to 3405 South Street 1,500 calories of eatables, ¼ protein and the rest half carbohydrate and half fat, the whole to cost fifty cents.'" It seems to put considerable responsibility on the grocer. One wonders if the time may not come when a doctor will say to a dietitian, "Plan a two weeks' dietary for that sick boy in room 101 in which the protein shall contain 2 per cent. trytophan, 5 per cent. tyrosin, 15 per cent. glycocoll," etc. The rôle of proteins in growth is fast becoming the rôle of amino acids and a difficult time is ahead of the dietitian. The accumulation of facts fills full the lives of one group of people; gathering and correlating the facts as they accumulate is enough to fill the lives of another group; and the practical application is far more than enough for another group. The groups are not in sufficiently close contact.

The body uses amino acids, but it must be fed proteins, and the amino acids it receives depend in amount at least not only upon the chemical composition of the protein, but upon its physical character and upon the other substances combined or mixed with it in the food. There has long been evidence that the proportion of ingested protein that is digested and absorbed from bread varies with the amount of grain cortex present, less being absorbed from the coarser varieties; that it varies in other foods with the amount of cellulose present. The much-discussed inadequacy of corn to serve as an exclusive ration, long thought to be due to the character of its proteins, has been shown by Hart and McCollum[2] to lie in its mineral content. When this is corrected, normal growth is possible on a corn ration. This, of course, is rather a misinterpretation than an actual modification of the utilization of the protein. Similarly, the apparent inability of some babies to utilize milk proteins is not unfrequently due to an excess of fat or of carbohydrate in the food. When this is remedied, the symptoms of protein indigestion disappear. We have found recently that the digestion of milk proteins is distinctly and

[1] Papers presented at the symposium before the Section of Physiology and Experimental Medicine of the American Association for the Advancement of Science, Columbus, December, 1915.

[2] "The Influence on Growth of Rations Restricted to the Corn or Wheat Grain," *J. Biol. Chem.*, 19, 373–97, 1914.

differently modified by the various carbohydrates commonly used in milk modification for babies.

In order, then, to consider the rôle of proteins in growth from the standpoint of the sources of our food supply, it is necessary to consider (1) the utilization of proteins, dependent on those characteristics of the proteins themselves or of the foods containing them, which make them resistant or not to the digestive enzymes or which influence the rate of their passage through the alimentary tract; (2) their assimilation; to what extent they can supply the essential amino acids in the proportion in which the body can use them for tissue building; and (3) the physiological effect of individual amino acids, especially, perhaps, those furnished by the proteins in question in excess of the body's needs.

The experiments of Mendel and Fine,[2] and more recently a shorter series by Howe and Hawk,[3] show that when fed in a more or less isolated form, the proteins of cereals are as completely digested and absorbed as are the proteins of meat—91–97 per cent.; but for the proteins fed in the natural foods these values do not hold. Only 80–85 per cent. of the nitrogen of wheat bread is absorbed, 70 per cent. of rye, 58 per cent. pumpernickel, 40.76 per cent. barley and 61–82 per cent. of corn nitrogen. These values for the whole grains were determined a good while ago by methods less accurate than those now in use, but they are at least comparable among themselves and they show, undoubtedly, lower protein utilization in grains than in isolated grain proteins.

This loss must be considered in planning the dietaries of young children, especially of those who can not take much milk. The proteins of cereals are as well utilized as milk proteins if they are fed in isolated form, but as long as dietaries contain not gliadin and glutenin and maize glutelin, but cream of wheat and hominy, we must count on a loss of 20–40 per cent. of the protein, if the data at present available represent facts. The proportion of the protein intake that comes from cereals is far from negligible in many children's dietaries, and it is unwise to get too close to the minimum protein requirements, especially as we do not know exactly what this minimum is. Hindhede's[4] surprisingly successful maintenance of body weight and good nutritive condition on an exclusive diet of potatoes and fat would indicate a high utilization of potato proteins.

With equal digestion and absorption, proteins may still differ greatly in their suitability for tissue construction and otherwise in their physiological effect. It has been found that 20 per cent. of the nitrogen absorbed from ingested zein is promptly excreted in the urine; over 40 per

[2] "Utilization of the Proteins of Wheat," *J. Biol. Chem.*, 10, 303, 1912; "of Barley," *ibid.*, p. 339; "of Corn," *ibid.*, p. 345.

[3] "Utilization of Individual Proteins as Influenced by Repeated Fasting," Eighth International Congress of Applied Chemistry, 19, 145.

[4] "Studies on the Protein Minimum," *Skand. Arch. Physiol.*, 30, 97–182.

cent. of gelatin nitrogen. Howe and Hawk found that the proteins of meat and of the commercial wheat preparation gliadin are equally well digested and absorbed, but when fed five days in equal quantity and in similar rations, gliadin gave a negative nitrogen balance of 1.3 g., while meat gave a positive balance of 11.3 g. A large number of proteins have been shown by Osborne and Mendel and others to contain all the amino acids necessary for growth: ovo-albumin, ovo-vitellin glutenin, maize glutelin, edestin, casein, lactalbumin.

Several natural mixtures of proteins such as those occurring in wheat, corn, oats, milk, respectively, have been studied, largely by Hart, McCollum[5] and their co-workers, and have been found to furnish the amino acids necessary for tissue construction. McCollum[6] has compared the protein mixtures in these grains with one another and with the protein mixture of milk as to their availability for growth. Of the nitrogen of cereals 23–24 per cent. is available, 45 per cent. casein nitrogen and 63 per cent. of milk protein nitrogen fed as milk. Evidently, the amino acids resulting from the digestion of milk proteins not only contain all the units necessary for tissue building, but contain them more nearly in the proportion in which they can be used than is the case with the other foods considered. If there is a shortage of one amino acid essential to the building of a body protein, the amount of that acid present determines not only the amount of tissue construction, the rate of growth, but determines also the proportion of the food protein that can be used for growth. The body can store very little reserve amino acid—nearly all that can not be built into protein is promptly deaminized and the nitrogen excreted.

These facts are also shown in a different way in recent experiments of Osborne and Mendel.[7] The growth of rats on 18 per cent. casein food was normal, on 12 per cent. casein food subnormal, but the addition of a small amount of cystin to the latter ration made it equal to the 18-per-cent. casein food in growth production. The utilization of the whole protein for growth was increased by an increase in the amount of the needed unit. Similar results were obtained by adding lysin to edestin.

These and similar investigations have thrown light on the nutritive value of individual amino acids: the aromatic amino acids are essential to maintenance; cystin, lysin, probably arginin and histidine, are essential to growth. Evvard suggests that cystin may be responsible for the darker and thicker hair of pigs whose mothers received rations rich in cystin during pregnancy; Lusk[8] in his study of the specific dynamic

[5] "Influence on Growth of Rations Restricted to the Corn or Wheat Grain," *J. Biol. Chem.*, 19, 373–97, 1914.

[6] "Value of the Cereal Grains and of Milk for Growth," *ibid.*, p. 323–35.

[7] "Comparative Nutritive Value of Certain Proteins in Growth," *J. Biol. Chem.*, 20, 351–78, 1915.

[8] "Investigation into the Specific Dynamic Action of the Foodstuffs," *J. Biol. Chem.*, 20, 555–618, 1915.

action of food stuffs, finds that glycocoll has a specific dynamic action of 100, alanin of 50.

Many of these results of nutrition studies can not be used with confidence in problems of human nutrition until more is known about the differences in the amino acid content of the flesh of different species. The pig can use 23 per cent. of wheat proteins for growth, but we can not yet be sure that this is true of the child; and so of many of the other very interesting and valuable contributions cited. They suggest wonderful possibilities—future possibilities—for the dietitian: a child who is undersized and frail can sometime be fed just the right combination of milk, eggs and cereals to furnish the amino acids he needs in the right proportion with no large excess of any one to overtax the excretory system or to overstimulate metabolism; a worn-out neurasthenic can be given just the right amino acids to replace worn-out tissue and enough glycocoll to stimulate metabolism—in gelatin perhaps. We have some slight clinical evidence that this last works out.

THE MINERAL NUTRIENTS IN PRACTICAL HUMAN DIETETICS

By E. B. FORBES

OHIO AGRICULTURAL EXPERIMENT STATION, WOOSTER, OHIO

IN consenting to present this paper I did so with the feeling that perhaps I have as good right as any one else to confess for all of us that we know very little about the subject. The suggestions I have to make then are offered in entire humility and with satisfaction only that we are on the road to more complete understanding.

My task is to point out the bearings of results of experiments in the field of mineral metabolism upon our irrational, uncontrolled and largely uncontrollable human dietetic affairs. Only in the case of infants, invalids, lunatics and convicts does it seem practicable to regulate the diet of human beings with the same rationality and particularity with which the successful live-stock farmer habitually feeds his animals. In spite of the difficulties of the task, however, and the indifference of most of us to the economic and rational aspects of our own eating, there are those dependent upon us who should have the benefit of our wisest counsel, even though we put ourselves in the position of saying, "you are to do not as I do but as I say."

In order to bring clearly to mind the basic principles of nutrition involved in this consideration I must enumerate the functions of the mineral elements in animal metabolism:

As bearers of electricity the mineral elements dominate the whole course of metabolism.

They conduct nerve stimuli, and play a leading rôle in the general process of cell stimulation.

They govern the contraction of the muscles, including those of the heart.

They compose the central agency for the maintenance of neutrality in the blood.

They enter into the composition of every living cell.

They compose supporting structures.

They assist in the coordination of the digestive processes.

They activate enzymes, and through their control of the chemical reaction of the blood and tissues they govern enzyme action.

They unite with injurious products of metabolism, and render them harmless or useful.

As catalyzers they alter the speed of reactions, and the rate of metabolism generally, as measured by oxygen consumption.

Through their effects on osmotic pressure they govern the movement of liquids, and maintain the proper liquid contents of the tissues.

Through their effects on surface tension they participate in the mechanism of cell movement.

Through their control of the imbibition of water by the colloids they govern absorption and secretion.

Through their control of the affinity of the blood for gases they govern respiration.

Finally, they control the state of solution, precipitation, mechanical aggregation, chemical association and ionization of the colloids which compose living tissue.

These then are some of the functions of the mineral elements. Considering their nature and importance, it is at once obvious that life could not endure if its complex mineral requirements were not automatically and constantly maintained in almost perfect adjustment. What then are the facts which warrant the practical consideration of this subject? They are that in pathological states these functions are somewhat deranged, and that life as we live it is in many respects highly abnormal, in the sense of differing from that to which human metabolism is attuned; and with our ever-increasing social differentiation life puts increasing stress upon the integrity of the body and its normal processes. In relation to food materials there are also important facts bearing on this matter of the mineral nutrients, for while highly developed processes of food manufacture and efficient world-wide transportation give us the greatest opportunities for correct dietetics that there has ever been, these same agencies open the way to greater unwisdom and abuse in dietetics than have been possible in our more primitive days. The net result is an obligation on our part to prepare a defense of knowledge against the misfortunes of prosperity.

It is my belief that anything like exact quantitative control of human mineral metabolism, as a practical measure, is as impossible as it is unnecessary; impossible first, because any kind of control of human dietetics is very difficult; second, because our knowledge of the optimum mineral requirements of human beings is especially slight and fragmentary; third, because the interactions of the mineral elements among themselves affect mineral metabolism in such prominent ways that fixed and definite statements of mineral requirements are quite apt to be misleading. And exact control in these matters is unnecessary because of the existence of safety provisions, for bridging over temporary deficiencies, of a perfection in harmony with the surpassing importance of mineral metabolism.

It is my belief, therefore, that in our present state of knowledge close statements of the mineral requirements of human beings involve a large element of "ceremonious delusion" (borrowing the expression from Thudichum), and that practical advice regarding the mineral metabolism of healthy human beings may most properly be general in character, and in the nature of recommendations of *types* of food products which should predominate in the diet under the various conditions of life, growth and activity.

We shall discuss certain of the mineral nutrients in detail, citing facts as to their occurrence in foods and metabolism in the body.

The one mineral salt which we use as such—sodium chloride—occupies a unique position among the mineral nutrients. Within wide limits it seems to make little difference how much sodium chloride we consume, and the kidneys excrete this salt without marked energy expenditure. Under certain conditions excessive intake of this salt causes slight increase in nitrogenous outgo, but such abnormal consumption would result in indigestion before the increased protein katabolism would become important in extent.

A special method and capacity of the kidneys for the elimination of sodium chloride is shown by observations of Schloss[1] and of Borchardt.[2] It appears that this salt alone fails to cause a loss of water from the body corresponding to the amount of salt eliminated.

Bunge relates our unusual appetite for salt to the potassium content of the diet, and the antagonistic relation between sodium and potassium which exists in metabolism. It takes such a quantity of potassium salt to cause an appreciable increase in the elimination of sodium, however, that I prefer to explain our peculiar relations to sodium chloride as due to the marine origin of vertebrates and the consequent adaptation of these forms to life in a somewhat concentrated solution of this salt.

Other physiological antagonisms which are often mentioned are

[1] Schloss, *Biochem. Z.*, 22, 283–89.

[2] Borchardt, *Deut. med. Wochenschr.*, 38, 1723–27.

those between calcium and magnesium and between calcium and sodium; other less important ones have been shown to exist between chlorine and iodine, and between chlorine and bromine.

The retention of the minerals is also prominently affected by their relative abundance in comparison with the requirement, that is, by the so-called "law of minimum," the least abundant constituent, as compared with the demand, serving largely to determine the usefulness of others with which it is associated in metabolism. The various salts of the diet also affect the solubility of others of this same group of nutrients in important ways.

The net result of these interrelationships among the mineral nutrients is likely to be manifest as a prominent lack of correspondence between the retention and the intake of these substances. The man to whom quantitative relations in mineral metabolism appear to be simple and direct is not embarrassed by an acquaintance with much of the evidence.

Calcium, phosphorus and iron are more likely than other mineral nutrients to be lacking in human dietaries. On this account especial interest attaches to their occurrence in food. Calcium is especially abundant in milk, and is also contained in considerable quantities in eggs, vegetables and fruits. Phosphorus is abundant in milk, eggs, nuts, peas, beans and such cereal products as contain the outer seed coats. Iron is found in largest quantities in beef, eggs, beans, peas, green vegetables (especially spinach) and in the outer seed coats of the cereals. The foods which are poorest in minerals are polished rice, pearl hominy, white flour, bolted cornmeal and other cereal foods which lack the outer seed coats. These foods, because of their highly digestible character and lack of salts, are apt to be constipating. Magnesium is abundant in the cereals and is not apt to be deficient in normal rations. The magnesium salts of the outer seed coats of cereals contribute a laxative character to foods containing them. Enough sulphur is contained in the proteins of any ration which supplies the nitrogen requirement. Potassium is found in considerable quantities in most normal foods and is also present in sufficient amount in almost all diets.

Manganese, boron, silicon and iodine are among the less abundant minerals in the body, the presence of which in the necessary quantities in the diet we take for granted. We are just now finishing up in my laboratory iodine estimations on about 950 samples of food products in a study which will show in what foods iodine is found, and which may perhaps show a relationship of the iodine of foods to the prevalence of goiter.

Considering the proportion of minerals to other nutrients needed during the several stages of life, there is, from birth to maturity, in general a decreasing requirement, but with periods of increased demand due

to unusual functional activity, especially during puberty, pregnancy and milk secretion. The usual mineral requirements of mature human beings are comparatively slight, and are probably satisfied by all normal diets (provided we specify with some particularity as to what constitutes a normal diet). It is, therefore, during rapid growth and during the reproductive life of women that the mineral nutrients are especially in demand, and it is at these times that lack of mineral nutriment and irrational hygiene cause or aggravate a number of well-known pathological conditions which are characteristic of these states of being. We shall mention in detail the mineral requirements at some of these times of greater need.

The normal food of the human infant naturally furnishes its full mineral requirement. This subject becomes of interest in this connection, therefore, in cases of artificial feeding and in certain metabolic derangements. For an artificial food we naturally turn first to cow's milk, which because of high fat and casein contents must be liberally diluted. If water is used, the necessary dilution reduces the minerals, the albumin, the lecithin and the so-called accessory nutrients to an undesirable extent. The best diluent is whey, which any one can prepare with the aid of a thermometer and a commercial rennet preparation in a few minutes. (The whey must be heated to 68°C. or 154° Fahrenheit to kill the enzyme, before it is mixed with milk.) With combinations of whey, skim milk, cream and milk sugar you can play any dietetic tune you please on the infant organism, and with these foods the intelligent parent can rear any infant which can live at all. The especial usefulness of whey is due to its abundant mineral content in natural physiological solution. It serves as a stabilizer—a corrective. You can do no harm with whey unless you use the evaporated preparation, whey powder. It is possible by an abuse of this food to cause edema (in weak infants) through excessive ingestion of minerals, though this would never occur in its proper use.

The commonest metabolic disturbance in infants is gastrointestinal indigestion. Its commonest cause is a weak digestive apparatus and too much fat in the food. Alkali soaps, formed in the intestine, instead of being digested and absorbed are passed off in the feces. Alkalis are lost to the organism; mineral acids are left to predominate; infantile acidosis ensues. What shall we do? Reduce the fat in the food and add sodium citrate to furnish an oxidizable alkali salt.

Because of its low oxidative capacity the infant organism is especially subject to acid intoxication from relatively slight causes, the acid excess being due to the normal acid products of metabolism and to imperfectly oxidized organic compounds, especially betaoxybutyric acid. We have mentioned the weak digestive apparatus and deficient capacity to handle fat. Inanition also causes acidosis in infants. Fever is a

very common cause. In all these cases whey is especially valuable. Many a child has been taken through long sieges of fever on whey. Children do not lose weight rapidly on whey alone. Egg white and fruit juice, especially that of the orange, may be used with whey to advantage; they furnish some nutriment and appreciable amounts of alkali.

The infant is born with a store of iron within its body. During the nursing period this store is gradually depleted, since the milk contains little iron. At weaning time the infant stands in need of iron. This is usually supplied in egg yolk, beef press juice, scraped beef, prunes, whole wheat foods and oatmeal, and some physicians of unquestioned standing recommend spinach. I happen never to have seen spinach used, however, for an infant. Egg yolk is of especial value as a source of iron, calcium, phosphorus and lecithin. But it is an exceedingly rich food. It must be fed with great care on two accounts, first, to avoid making the baby sick, because while it is usually well taken it acts like poison to some infants, and second, because the value of egg is so great that it is especially unfortunate if you upset the infant by an overallowance, since it may be a long time before it will regain its tolerance for this food.

In connection with the mineral metabolism of infants mention must also be made of rachitis. The cause of this disease is unknown. It is not due *primarily* to lack of minerals in the diet and does not respond readily to simple increase of minerals in the food, though calcium salts administered with phosphorized cod-liver oil are usually beneficial.

The existence in infants and older children of simple malnutrition of the bones, a common malady in young farm animals, is not well established; and the prevalent imperfections of children's teeth are not certainly related to deficiencies in the diet, but seem rather to be caused by lack of exercise (due to the fine milling of our cereals and the chewing of our meat with a sausage mill), the increasing use of sugar (a readily fermentable, acid-producing food) and increasing use of fruits, the organic acids of which soften the tooth enamel.

In considering the mineral requirements of human beings we may bear in mind the facts that more than three fourths of the ash of the body is in the skeleton, which includes about 88 per cent. of the phosphorus and more than 99 per cent. of the calcium of the entire body. Thus in discussing mineral requirements of the organism as a whole we have to do very largely indeed with the skeleton, but we must not overemphasize these facts, for the quantities involved are no gauge of functional importance, as is illustrated by the fact that iodine, which is found in the body in infinitesimal amounts, is just as essential as the pounds of calcium.

Beyond the period of infancy the mineral nutrient which is most commonly lacking in the diet is calcium, though phosphorus also may be

deficient, and the iron content of the diet is sometimes inadequate, as evidenced by the existence of anemia in children.

For purposes of growth our best single sources of mineral nutriment are milk and eggs. Of these, milk lacks only iron, and eggs only calcium. The incubating bird supplements the moderate calcium content of the egg by absorbing an appreciable amount of lime from the shell.

During the reproductive life of women liberal use should be made of the iron-containing foods, such as beef, eggs, fruits and green vegetables, especially spinach, green beans and cabbage. Lactation makes a heavier demand upon the mother for mineral nutriment than any other incident in her life, and the most efficient method of providing the mineral requirement is, naturally, through the use of milk, or foods made from milk.

In old age there seems to be an absorption and loss from the body of much bone substance coincident with the general atrophy of the tissues. This is most apparent in the receding of the processes of the maxillæ and the absorption of the spongy structure of the interior of the long bones. This appears to be a physiologic process, and we have no evidence that it is affected one way or the other by the minerals of the diet, though it is conceivable that there might be some such influence.

Generally speaking, a high ash content of the food is desirable, since the organism is much better able to handle an excess of ash constituents than to meet a deficiency. It is good practise, therefore, to utilize the water in which foods are cooked, in so far as this can be done without detracting from the acceptability of the food, since the cooking-water dissolves out much mineral matter. An abundance of mineral salts in the diet is also desirable, aside from nutritive considerations, because they contribute a laxative character to the food. Foods which are deficient in minerals are apt to be constipating.

A general character of the mineral nutrients of foods is the predominance of acid or basic elements. If the nutrients are present in the proportions in which they are needed the bases will predominate, and it is probably best that the bases should exceed the acid elements in the diet. It is true, however, that the organism has the capacity to neutralize a considerable excess of acids. Meats, eggs and cereals have acid ash; vegetables, milk and most fruits have alkaline ash. The latter group should be liberally represented in the diet.

The diets which are most likely to supply enough of each of the minerals are those characterized by liberality and diversity. Extreme simplicity of diet is not advantageous. The usual diets of prosperous Americans do not lack mineral nutrients. But we are not all prosperous, and some of us choose unusual dietetic combinations. The central features of improperly chosen diets are usually an undue dependence upon meats and foods made from finely milled cereals or other cereal

foods lacking the outer seed coats, and too little use of milk and vegetables.

Those circumstances most likely to lead us into error in this matter are ignorance, poverty, parsimony, dietetic fads, peculiarities of appetite and disordered digestive functions.

Now in conclusion, it is certainly true that we muddle along fairly well without much attention to this subject, but one never knows when he may need additional insurance in the way of understanding. Through my slight knowledge of this subject I was able to save my own son, and that of course seems to me to have been worth while. Then too, when there be no lives in danger, there is a certain satisfaction which we all take in efforts to direct our affairs with intelligence even though "the worst laid plans of mice and men gang oft aright."

THE CHEMICAL NATURE AND PHYSIOLOGICAL SIGNIFICANCE OF SO-CALLED VITAMINES

By CARL VOEGTLIN

PROFESSOR OF PHARMACOLOGY, U. S. PUBLIC HEALTH SERVICE

IT has been known for some time that scurvy is a disease which occurs in man and certain higher animals when the diet does not contain fresh vegetable or animal foods. Once the disease has made its appearance it can be cured in most cases in a remarkably short time by the introduction into the diet of the patients of a sufficient amount of fresh vegetables, fresh milk and especially fresh lemon juice. Hence it is obvious that these last-mentioned foods contain in their fresh state substances which are essential for the prevention of scurvy. As a diet which otherwise is fully adequate from the point of view of its content in proteins, carbohydrates, fats and calories may lead to scurvy, the logical conclusion is that there exist in fresh vegetables and certain animal foods substances of an unknown chemical composition which are essential accessory foods.

The deficiency of the diet in similar substances may give rise to a disease of the peripheral nervous system, known as beri-beri, which is especially prevalent in eastern countries, as Japan and the Philippines. People living on a diet which consists almost entirely of highly milled rice or wheat are very apt to develop beri-beri after having lived on this diet for a period of ninety days. On the other hand, beri-beri does not develop in persons living on whole rice or wheat flour. In other words the outer portions of these cereals, namely the aleuron layer, contain the substances which have to be added to the diet in order to prevent this disease. As in the case of scurvy, a considerable number of observations have established the fact that beri-beri is not due to a deficiency of the

diet in proteins, carbohydrates or fats, but that certain accessory food substances are lacking in the diet. For this reason we speak of scurvy and beri-beri as deficiency diseases, meaning by this term that the diet which is responsible for the production of these diseases is deficient in certain accessory foods having no direct relation to the protein, carbohydrate and fat content of the diet. Funk has designated these accessory foodstuffs as vitamines, meaning that they are essential for life.

It is fortunate that most people on account of their dietary habits live on a mixed diet containing enough of these accessory foods to prevent an outbreak of scurvy or beri-beri. Little can be said, however, at the present time as to the influence of a deficient diet on health, the deficiency of which is not pronounced enough to produce scurvy, beri-beri and other, as yet unrecognized, deficiency diseases. It is only reasonable to assume that such an incomplete deficiency might lead to milder symptoms which are only fully pronounced when the disease has made its appearance. From the foregoing it is evident that the scientific and practical importance of these accessory foodstuffs or vitamines can not be overestimated and their bearing on nutrition and the maintenance of health represents a most interesting scientific chapter. I shall therefore attempt to review the most important discoveries which have been made in the last few years in this field.

The first fact which seems fairly well established is that the substances preventing beri-beri or the anti-neuritic substances are present in the natural foods largely in a combined form which is soluble in 90 per cent. alcohol or water, and when present in sufficient amounts in the diet will prevent the occurrence of beri-beri. This mother substance can be split by means of acid hydrolysis or autolysis by means of enzymes, yielding after fractionation a substance with very powerful curative properties if tested on patients with symptoms of beri-beri; especially the so-called wet beri-beri is cured by this preparation in a few days. Very little is known at present as to the chemical nature of the mother substance of this beri-beri vitamine. The observations that foods rich in lipoids are also rich in vitamines and the solubility of the mother substance of the anti-neuritic substance in alcohol might lead to the belief that vitamines enter into the molecule of certain lipoids, an assumption which recent experiments by Dr. Sullivan and myself[1] have made highly improbable. The anti-neuritic vitamine is probably not in combination with carbohydrates, as the starchy part of cereals seems to be extremely poor in this substance. The possibility that certain parts of the protein molecule, especially the nucleic acids, may hold in combination the active substances is still open and the fact that foods rich in nucleated cells are also rich in anti-neuritic substance might perhaps be considered as evidence of the truth of this assumption.

[1] *Proceedings Amer. Soc. Biol. Chemists*, 1915.

From these considerations we may conclude that the anti-neuritic vitamine is present in foods in a combined form, which is much more resistant than the free curative substance. This is of great practical importance, as in the process of cooking we subject food for a considerable length of time to a temperature of about 100° C. As will be seen later, the more or less isolated beri-beri vitamine loses its physiological activity under these conditions.

It is obvious that the chemical isolation of vitamine from foods is of great importance in order to enable us to study their chemical nature and physiological action. A considerable amount of work along this line has finally led to some degree of success. We are especially indebted to Funk[2] for a method which makes it possible to obtain the anti-neuritic substance in a more or less pure form of very powerful physiological activity. This investigator succeeded in preparing a crystalline substance, a few milligrams of which when administered to pigeons suffering from experimental beri-beri led to a complete recovery of the paralytic symptoms within a few hours. This substance contains carbon, nitrogen, hydrogen and oxygen. It seems to possess the properties of an organic base. Unfortunately the yield in active substance is very poor, even when prepared from hundreds of pounds of natural foods rich in this substance. This is due to several defects in the method. First, it is at present impossible to extract the total activity from natural foods by means of alcohol, the common solvent used for this purpose. Second, the use of alkalies and oxidizing agents employed in Funk's method destroys the anti-neuritic vitamine very easily. Work is in progress in my laboratory to overcome these difficulties and I may state that several new modifications of the method have been discovered which seem to improve the yield considerably. It is interesting to note that adsorbing agents, such as charcoal, etc., will completely remove the anti-neuritic substance from its solutions. Such solutions also lose their physiological activity by boiling for a few minutes after sufficient alkali has been added to render such solutions alkaline.

As far as the anti-scorbutic vitamine is concerned it has been impossible to isolate it up to the present time. All we know about this substance is that it is fairly stable in acid media. This is probably the reason why lemon juice, with its high acidity, is the classical preparation used in the prevention and treatment of scurvy.

For the same reason milk, having an amphoteric reaction, on being heated for a considerable length of time to a temperature exceeding 100° C. loses its anti-scorbutic properties and in forming the exclusive diet of children may give rise to the appearance of infantile scurvy.

The physiological and pharmacological properties of these vitamines have not been studied extensively. The main facts which have been

[2] C. Funk, "Die Vitamine," 1914.

established are that these preparations, obtained in the proper way, do not possess toxic properties, and that in remarkably small amounts they relieve the symptoms in animals and men suffering from deficiency diseases. The mechanism of this pharmacological action is still obscure. Observations made on the vitamine content of the spinal cord have shown that nerve fibers do contain the anti-neuritic substance, mainly in a combined form, which is liberated after autolysis of the tissue. From this it would appear that the anti-neuritic substance under normal conditions formed an essential part of the nerve fiber, and its presence in nerve tissue in sufficient amounts is essential for the proper function of this organ.[3]

An interesting relation between carbohydrates and anti-neuritic substance was discovered by Funk,[4] Braddon and Cooper.[5] It was found that in order to prevent the occurrence of experimental beri-beri in pigeons it is necessary that for each gram of carbohydrate in the diet there must also be present a certain minimal quantity of anti-neuritic substance. If the carbohydrate component of the diet is increased the vitamine content must be increased accordingly. This explains the earlier observations that a diet rich in carbohydrates is more apt to give rise to the appearance of beri-beri.

In conclusion a few considerations concerning the practical bearing of these accessory foods or vitamines on nutrition in health and disease may not be out of place. The following table illustrates the relative vitamine content of foods, beginning with those richest in vitamines. I do not pretend that this table is a very accurate compilation, but in our present state of knowledge it will probably be found of some use in deciding questions as to what constitutes a satisfactory diet from this point of view.

TABLE

Anti-neuritic Properties		Anti-scorbutic Properties	
Relatively Rich	Relatively Poor	Relatively Rich	Relatively Poor
Brewer's yeast	Sterilized milk	Fresh vegetables	Dried vegetables
Egg yolk	Sterilized meat	Fresh fruits	Dried fruits
Ox heart	Cabbage	Raw milk	Sterilized milk
Milk	Turnips	Raw meat	Canned meat
Beef and other fresh meat	Carrots and other vegetables of this type		Dried cereals
Fish	Highly milled cereals		Pork fat
Beans	Starch		
Peas	Pork		
Oats			
Barley			
Wheat			
Corn			

[3] Voegtlin and Towles, *Jour. Pharmacol. and Exp. Ther.*, 1913, Vol. 67.
[4] Funk, *Zeitschr. f. physiol. Chem.*, 1914, IX. C., 378.
[5] Braddon and Cooper, *Jour. Hyg.*, 1914, XIV., 351.

It is obvious from this table that a mixed diet including sufficient animal foods, as fresh milk, eggs, meat and fresh vegetables is by far the most satisfactory diet, as it contains sufficient anti-neuritic and anti-scorbutic substances. The dietary habits of the greater part of the population in this country are such as to prevent the continuous consumption of a diet deficient in vitamines. In recent years, however, certain factors have had a tendency to reduce the vitamine content of the diet of the population at large. Changes in our economic conditions, food production and method of cooking seem to reduce the vitamine content of the diet of a large number of persons to the danger-point. Observations which I have made in connection with studies on the cause of pellagra bear out this assertion. The population of a large portion of the southern states, in which this disease is prevalent to such a serious degree, lives on a diet which is, to say the least, not rich in vitamines. Highly milled cereals, pork fat, in addition to cabbage and turnips and similar vegetables, form the staple article of the diet. The customary use of baking-soda in the preparation of food furthermore lowers the vitamine content of the diet. I have been able to demonstrate on animals that corn bread made from cornmeal and milk with the addition of soda loses its high initial content of anti-neuritic substance in the process of baking as a result of the destructive action of the alkali. The use of baking soda for this purpose should, therefore, be discouraged.

Another factor which undoubtedly enters into this question is the consumption of highly milled cereals. The staple articles of diet of a great percentage of the people in the southern states are highly milled wheat, corn and rice. The change in the milling process, leading to the making of these products deficient in vitamines, took place in more or less recent years.

The increase in the cost of living naturally tends to reduce the amount of the more expensive milk, meat and eggs in the diet and leads to a corresponding increase in vegetable foods, the latter being deficient in certain accessory foods. While it is not yet firmly established that pellagra is a deficiency disease, many facts speak in favor of such an idea. Without exaggeration it should be stated that the importance of the accessory foods is a vital problem for the maintenance of the health of the human race.

FOOD SELECTION FOR RATIONAL AND ECONOMICAL LIVING

By C. F. LANGWORTHY

CHIEF, OFFICE OF HOME ECONOMICS, STATE RELATIONS SERVICE, U. S. DEPARTMENT OF AGRICULTURE

THERE are a number of factors which should be taken into account when one discusses diet with reference to its adequacy and economy and to the satisfaction which it gives. Among these are a knowledge of local markets and standards of food quality; wise selection of food; preparation and cookery; and the planning of meals, or, as it is so commonly called, "menu-making." The last of these is by far the most important, and will therefore be discussed at the greatest length, though the others logically precede it.

By a knowledge of markets is meant not only knowledge of the location of butchers, grocers and other dealers in food in one's neighborhood or town, but also a good idea of the reliability of the different dealers, the quality of the goods which they offer, the relation of the cash or credit systems of selling to their prices, and other such things. To be complete it should also include some understanding of the production and distribution of food materials; such information, for instance, as would lead the housekeeper to purchase local-grown goods when possible, not only because they may be fresher, but also because of the difference in their favor of transportation charges and hence of price. With respect to the quality of foods, the housekeeper should know, for instance, how to distinguish old and young poultry, and tough, overfat or overripe meats; she should know the relative merits of wilted and fresh vegetables, being able to tell when the former can be freshened or when they include too much inevitable waste to be economical. Other illustrations might be cited, but these are sufficient to show what is meant. A knowledge of markets and of quality of food products as related to final value calls for a wide range of information, much of which can be taught and some of which must be gained by experience.

Wise choice of foods involves possession of other lines of information and experience which enables the housekeeper to purchase to good advantage. She must realize that out-of-season foods, like strawberries or green peas in January, will be more expensive, and no more nutritious, than the same foods in early summer, while foods which are uncommon at all times, like fresh mushrooms, will be more expensive than cabbage or carrots, which they closely resemble in nutritive value. She may select according to her circumstances, but she should do so "with her eyes open," and not in the belief that the superior virtues belong neces-

sarily to the rare or the unusual. Then, too, one must take into account the quantities which can be handled advantageously in the home. It is the part of wisdom to purchase in quantity those supplies which can be easily stored and kept without deterioration, while such purchase would be decidedly unwise in the case of perishable foods, or if there are no proper storage facilities. One must take into account further the ability of the person who cooks to make acceptable dishes from the foods supplied. If she does not know how to make a palatable pot roast or similar dish from a tough cut of beef and does know how to broil a steak well, there may be some economy in choosing the steak. The suitability, with respect to the needs of the individual family, of the food purchased, is another important consideration. Thus, a good deal of waste comes from the purchase of meats which give too large cuts for the family tastes. For instance, if the chops purchased are so large that the individual portion which would be served (usually one large or two small chops) is larger than the eater's average appetite, part of the meat may be left on the plate and thrown away. The housekeeper, therefore, should take pains to provide materials which can be served in portions to "fit" the family tastes.

The relative amount of time, labor and fuel which is required in preparing foods for the table has a decided influence upon actual as compared with apparent cost. The busy housekeeper who wishes to prepare breakfast quickly may recognize this when she pays a higher price per pound for some ready-to-eat cereal, which at most only requires to be warmed before serving, instead of buying a breakfast cereal costing less per pound but which must be cooked for several hours. If she prefers a cereal which needs longer cooking, she should know that she can begin to cook it when the evening meal is prepared, and finish it either in the fireless cooker or while she is preparing breakfast the next morning. The more she appreciates and acts upon such considerations, the more likely she is to provide a satisfactory diet which is also an economical one.

Cookery and other matters pertaining to the preparation of food for the table are particularly important from the standpoint of economy and satisfaction. Here, as elsewhere, knowledge of the "art of dressing food," to use an old phrase, is very important. It may be learned by experience (usually at much cost), or from the mother or other members of one's family, as has been the rule in the past, or, like other arts, it may be learned in school, as is increasingly the case under the changed conditions of the present day. The housekeeper needs such knowledge, whether she applies it herself, or whether she directs some one else. If, in addition to the art of cookery, she understands relative food values and other technical matters pertaining to food and its uses, her task of providing a rational diet will be the easier.

She should not be parsimonious in her household management, neither should she be extravagant, and to this end she should understand and practise rational economy. She must realize, for instance, that a large amount of garbage means needless waste, due to carelessness, to excessive purchase, to overgenerous service, to poor cooking, or to menus which do not please the members of the family.

She should be familiar with economical practises and usages and with practical ways of saving materials, having wisdom to make use of those which are really worth while and to avoid those which merely seem economical. As an illustration, it is possible to be economical in the use of fat and yet keep up a good standard of living. This implies careful use of the fats purchased for the table and for cooking, and also the use of fats commonly thrown away. The proper "salvage" and use of chicken fat, rendered suet, bacon fat, and other fats commonly wasted, which are, so to speak, by-products of raw materials or of cookery, will enable her to economize in the amount of butter and other fats purchased as such. She may take a hint from the commercial baker, who realizes that stale bread and cake, dried and ground, can replace about one fourth of the flour used in making many kinds of cookies, cakes, and other foods. She must appreciate the importance of careful preparation of food materials and recognize that thin paring of fruits and vegetables is less wasteful than careless paring, and that soaking dried foods like navy beans, dried peaches, etc., before cooking them economizes fuel by lessening the time of cooking required. She must know that it is possible to make palatable yet economical dishes by extending the flavor of some more expensive food through a fairly large proportion of a cheaper food of blander flavor, as is done when a small amount of meat is combined with a large proportion of potatoes, carrots, and other vegetables in making a meat stew. On the other hand, she should see that it is poor economy to use a pint of cream and several eggs to save a cupful of cold boiled rice or farina which might better go into the soup kettle.

The last factor, namely, the planning of meals, is very important and places a great responsibility upon the housekeeper, since it determines whether or not the diet provides the body with all the materials it requires. It is a problem which is often well solved by the housekeeper on the basis of empirical or other knowledge, but which is almost certain to be wrongly solved if such knowledge is lacking. Certainly, it is one regarding which there is much ignorance and many misconceptions. At one extreme are those, and they probably represent the great majority, who consider their meals only in reference to palatability—a selection which may be rational if they have learned good food habits, and fortunately, there is much empirical teaching on food habits which is sound. At the other extreme are those who heed all the fantastic statements they come across regarding specific medicinal or even semi-magic virtues as-

cribed to certain foods, who place their hopes in some particular type of food materials, or who fear lest they may suffer by "eating incompatibles," and so on through the long list of dietetic fads and fancies. Many, however, are not long deceived, their common sense warning them that, if such doctrines were true and important, the race could hardly have survived its alleged dietary indiscretions. Between these extremes stand a rapidly increasing number who seriously desire to understand and apply the principles of dietetics as they are now expounded by the more generally accepted authorities.

A fundamental principle is that the diet, considered for any reasonable length of time, must supply a great variety of chemical substances combined in different ways for the "structural" needs of the body, and also must supply it with energy-yielding substances with which it may perform internal and external work. It seems apparent that a varied diet, reasonably generous in amount, is more likely to meet the body needs than one restricted or unvarying in its make up or scant in quantity. The more knowledge and judgment used in its selection, the better the diet is likely to be.

In discussing diet, the expression "balanced ration" is often used, no doubt because it occurs so often, and to such good purpose, in discussions of animal feeding. Those who employ the term should remember that the feeder of live stock not only selects the kind of food which the horse or the steer is to eat but measures the quantity. The housekeeper, the physician, and the nurse do this for the infant and sometimes for the person who is ill or otherwise compelled to live under circumstances in which the diet is definitely controlled. The housekeeper does not do this when under normal conditions she provides a meal for her family to select from and eat of at will. Such freedom of choice is compatible with rational living and should for the best ends be accompanied by rational food habits which can be early taught in childhood, or, if need be, acquired later in life. Therefore, the term "balanced" is, and is likely to remain, inaccurate for general discussions of dietetics, and the term "well-selected" should be given the preference.

The character of the meals which the housekeeper will provide is determined largely by racial and regional influences and also by fashion. In the United States the general character of the diet is like that in the British Isles, with many minor modifications contributed by the other races which go to make up our population. Thus, we have meat with potatoes and one or more other vegetables and a dessert for the simple dinner, with the addition of soup and salad for a more elaborate one. As an example of foreign influence may be cited the serving of macaroni and cheese as one of the vegetables at dinner, or the use of sauerkraut with pork.

The influence of fashion or custom is shown in such a matter as the

preference for a meal of a given type; for instance, the continental breakfast of rolls and coffee in comparison with the English breakfast of jam, toast, eggs or meat, and tea, or the American breakfast of which fresh fruit and breakfast cereal so commonly form a part, usually accompanied by more hearty foods. We may prefer one type or another, because we have always known it or because we have learned to like it, but the whole matter is chiefly one of custom; and it is the same way with other meals. Fashion also governs quite largely the choice and the combinations of foods for a given meal; for instance, there is no inherent reason why peas instead of string beans should be served with lamb, or why we should serve apple sauce with pork and currant jelly with mutton rather than the other way around. We instinctively follow conventions, but we must not overlook the importance of so following our preference that we get distinct variety from meal to meal and from day to day. The housekeeper who thinks about such matters will realize that serving sweet potatoes, white potatoes, Hubbard squash, and boiled rice at the same meal shows "poverty of invention," since she will realize that they are somehow alike, even if she does not know that all are characterized by the presence in relatively large proportion of carbohydrates. Nor would she be happier in her choice if she served such a combination of green vegetables as spinach, asparagus, cabbage, and cauliflower, since all are similar members of the green vegetable group. Most palates would be better pleased if she had scattered her dishes through several days, having white potatoes and spinach, for instance, on one day; asparagus and sweet potatoes on another day; and so on through the almost endless number of combinations of which the food list permits; and had included in the menu such other types as seed and fruit vegetables (green beans and peas, tomatoes, cucumbers, green corn, melons, and so on). Not only would this be more pleasing to the person with discriminating taste, but it would also be more desirable from the standpoint of the rational selection of foods, since a person would be more likely to secure all of the food constituents which he needed from a mixed meal than from one of such sameness.

Furthermore, a survey of the available data on the subject of meals leads us to believe that it is possible to classify them into two distinct types (though admittedly this is only a very rough division)—namely, those which, for want of a better term, may be called the "hotel" or "restaurant" type and those which may be called the "family" type. In the former the principal dish chosen is likely to be a meat order, which may carry with it a moderate serving of potato and which is supplemented chiefly by bread and butter and possibly dessert, and less often a green salad, but which usually does not include a generous order of vegetables. In the second, or "family," type of meals the amount of meat served is likely to be smaller and the proportion of vegetables

served very much larger, with dessert and bread and butter as well. If we follow the rapidly gaining theory that foods like meat, which yield an acid residue when assimilated, should be accompanied by a generous amount of foods like vegetables and fruits, which yield a distinctly alkaline residue when assimilated, the wisdom of the so-called household type of meal is apparent. We shall find also, if we consider its chemical composition and energy value, that it is more likely than the other type to supply in reasonable proportion the necessary building and repair material and the energy-yielding substances required.

The number of meals taken in a day is significant chiefly as a convention or fashion. With the reasonably generous breakfast of the American family the lunch or supper is likely to be moderate and the dinner generous. On the other hand, it is natural enough that with the light breakfast of Continental Europe there should go either the second breakfast and supper or the hearty lunch as well as the dinner. Apparently the number of meals taken does not greatly influence the amount eaten per day, for the man who goes without his breakfast is very likely to make up for it at dinner or supper, while the man who eats an early breakfast and then a second breakfast will be likely to take a moderate lunch or a light dinner. Good food habits do not permit of gluttony.

The housekeeper who tries to provide a varied menu should realize that in general variety can be secured in two ways, either by using a considerable number of dissimilar food materials or by using varied methods of cookery with a smaller number of food materials. While both methods have their uses and both should be taken advantage of, it is well to remember that the first is the one more likely to provide variety from a chemical standpoint.

As regards the amount of food required, satisfaction and rational living demand that the amounts provided should be adequate, while economy demands that the amount should not be so great as to lead to over-eating or to needless waste. It may seem generous to serve a person more than he can eat, but it is not wise, since it means material left on the plate, only to be thrown away. It is better to give a smaller serving and offer a second helping. Proper care in such matters as well as in the selection and preparation of food should mean a considerable saving. The possibility of saving is made clear by the fact that the waste observed in studies of several hundred American families ranged from practically nothing to 20 per cent. of the food purchased.

It is also apparent that good dietary habits are important. These can be taught and are best learned in childhood. We should not allow children to grow up with whims, fancies and aversions respecting their food. They can be taught to like all the ordinary foods, and this should be done unless it becomes apparent (and this rarely happens) that some article of diet is distinctly harmful because of an idiosyncrasy toward it.

For the guidance of the food expert (dietitian or other specially trained worker), dietary standards have been proposed which show the proportion of protein and energy which the daily diet should supply. Such dietary standards are designed as guides for home and institution management, and should not be confused with expressions of physiological requirement. In quantitative discussions and in comparisons, one should always distinguish clearly between "food purchased," "food eaten" and "food digested," and should take the further precaution not only to compare like things, but to compare them on a uniform basis. The basis most often selected for comparing dietaries is the food or diet of "a man in the period of full vigor weighing 150 pounds and engaged in moderate to active muscular work," and factors for computing the requirement of men, women and children in other circumstances in terms of this standard have been worked out. These precautions should always be taken in comparing the results of dietary observations, experiments and studies; otherwise, avoidable confusion results. If they are so taken into account many of the seeming differences of opinion which sometimes lead to divergent conclusions will be found non-existent. When all precautions are taken for accuracy in comparisons and discussions, differences in the amounts of protein and energy found in the diet of different persons and different races are still apparent, as well as differences of opinion as to the amount of nutrients and energy required or desirable. Such differences of opinion, however, are not so great as one might expect, and one may well conclude, from a survey of the dietary studies of different races available, that persons of like age, sex and work, given an opportunity to select, instinctively choose diets showing, when reduced to uniform terms, a decided similarity with respect to the protein and energy they supply. This is not surprising when one recalls that all reasonably normal men possess bodies and possibilities of using them which do not vary within such very wide limits. A steam-engine of a given size and type will require the same amount of fuel of a certain kind in Asia as would a duplicate engine in America, for the production of a like amount of power, and why should this not be true of the human engine as well?

A large number of dietary studies made in the United States considered in comparison with the other large number made elsewhere have led to the conclusion that not far from 100 grams of protein per day, along with 3,000 to 3,500 calories of energy, represents, for the typical man (in the period of full vigor, engaged in moderate to active muscular work), the quantities which the food purchased should supply. We have not as yet been able to test with any degree of certainty the protein optimum though data on the subject are abundant enough to indicate that the suggested value represents common race habits. With energy the case is different, for it is possible with the respiration calo-

rimeter to test the accuracy of the value suggested in any given dietary standard. Such tests show that the values given above are in accord with actual measurements of the energy expenditure of individuals under the specified circumstances of work and rest.

A consideration of the results of American experiments and other data has led us to conclude that with our ordinary food habits, involving, as they do, the use of a considerable variety of foods in reasonably liberal quantities, one is justified for many purposes in discussing dietetics on the basis of energy only, since a diet which supplies 3,000 to 3,500 calories of energy per man per day, as ours so very commonly does, almost inevitably supplies the needed protein, ash, and other constituents also. Particularly is this the case when one takes pains to include in the diet a reasonable amount of milk, green vegetables and fruit. If we accept this conclusion as rational, it enables us to go ahead without controversy until the time comes when we have more abundant knowledge of the kinds and quantities of protein we need, of the functions of mineral elements and the best ways to meet our body needs for them, and of the nature of vitamines or other regulatory substances.

It is no new thing to realize that, although empirical knowledge and experience may lead to really good results, it is easier to achieve them if there is also special knowledge and training. Thinkers and writers in the past have given their time and attention to the problems of dietetics and have left us much which is interesting and useful. That we can discuss the problems more fully and more adequately at the present time is due to the great progress made in biology, physics, chemistry, medicine and other sciences. The question comes, how can we best translate the results of scientific investigation for the housekeeper's benefit. It was natural enough that at first we should try to do this in laboratory terms and expect the housekeeper to learn them. As a result, books, pamphlets, charts, etc., have been provided for her which in many cases can not be understood without special training, and for this time and opportunity are only too often lacking. Later has come the realization that, while the specialist who follows home economics as a profession needs wide and varied technical knowledge, the woman who practises the art of housekeeping chiefly needs, aside from the skill which she gains by experience, simple statements of facts and definite methods by which she may obtain desired results. With this realization has come the attempt to formulate more simple and pedagogically correct methods of instruction, and to provide illustrative material in pictorial or graphic rather than tabular and diagrammatic form. It starts with materials and facts familiar to the housekeeper and, as far as possible, applies standards which have been tested in practical as well as experimental use. Its advocates believe that by thus bringing practise and theory into direct and vital connection, their teaching is more likely than either the

scientific or the empirical method of instruction not only to result in more rational housekeeping, but also to supply the element of culture which raises any labor to an occupation.

In its studies of methods for imparting information through its extension and other activities, the Department of Agriculture has endeavored to classify common foods in a way corresponding to their distinctive functions in nutrition. The division must be more or less arbitrary, for some foods could go almost equally well in two or more groups. Thus milk, which is a general food, is included with the protein foods because it is a valuable source of this nutrient. Bread is a carbohydrate food, a protein food, and an ash-yielding food, but it is classed as a carbohydrate food because its most obvious constituent is starch, and because we use it in the same general way as we do starchy foods like potatoes. The classification as now arranged consists of five groups, and it is the understanding that each of these groups should be represented, if not at every meal, at least once a day, and that if an excessive number of food materials from any one group are used in the course of a day the result is likely to be unsatisfactory from the standpoint of rational dietetics or of taste.

The groups may be described in terms of the dietitian as follows: (1) Foods in which protein bears a higher proportion to fuel value than it does in the well-chosen diet as a whole; (2) those in which fuel value is high in proportion to protein, owing chiefly to the presence of much starch; (3) those in which fuel value is high, owing to the large percentage of fat; (4) those whose chief value is mineral constituents and vegetable acids (the latter important from the standpoint of flavor as well as of body needs); and (5) those which (like the foods in Groups 2 and 3) have a high fuel value, but in this case due to the presence of sugar. From the standpoint of fuel value only, it is obvious that Groups 2 and 5 could be combined. From the standpoint of the well-chosen and palatable meal, on the other hand, they should be kept distinct, since sugar is frequently as important as a flavor as it is as a food.

In housekeepers' terms the groups may be described as: (1) Flesh foods (except the very fattest), milk, cheese, eggs and such meat substitutes as dried beans, peas, and other legumes, and some of the nuts; (2) starchy foods; (3) fat foods; (4) watery fruits and vegetables (excluding dried legumes and fruits which have been dried or combined with much sugar); and (5) sweets.

The grouping is easy to remember and provides a guide for the housekeeper in the selection of food materials for a meal or for a day's ration and also a means of checking up and criticizing the meals which have been served.

It is obvious that while some foods belong clearly to one group, sugar and honey to Group 5, for example, and liver and veal (which contain

SOME COMMON FOODS GROUPED ACCORDING TO THEIR CHARACTERISTICS

(All five groups should be represented in the diet every day)

Group 1	Group 2	Group 3	Group 4	Group 5
Foods Characterized by Protein	Foods Characterized by Starch and Similar Carbohydrates	Foods Characterized by Fat	Foods Characterized by Mineral Substances and Organic Acids	Foods Characterized by Sugars
Lean meats	Bread	Butter	Spinach	Sirup
Poultry	Crackers	Cream	Peas	Honey
Fish	Macaroni	Lard and other culinary fats	Lettuce	Jellies
Oysters, etc.	Rice	Salt pork	Potatoes	Dried fruits
Milk	Cereal breakfast foods, meals and flours	Bacon	Turnips	Candy
Cheese		Chocolate	Apples	
Eggs			Oranges	
Dried legumes			Berries	
Nuts				
And other protein-rich foods	And other cereal foods	And other fatty foods	And other vegetables and fruits, raw or cooked	And other sweets

very little fat) clearly to Group 1, other foods are difficult to classify. Mutton, for example, is a protein food which might also be classed as a fat food, and dried navy beans might be classed as a protein and also as a starchy food. To cite another example, potatoes, which are an important source of mineral substance, with some organic acid, are included in Group 4 rather than in Group 2, which at first thought might seem the more logical place for them when we recall that they are so generally used as a source of carbohydrate (starch). In general, however, the system of groupings will be found helpful.

The following sets of menus contain none but wholesome and desirable food materials. These food materials, however, have been poorly combined so far as the protein, fat, and carbohydrate which they provide are concerned. The first set is characterized by much protein, the second set by much fat, and the third set by much carbohydrate.

MENUS WITH PROTEIN PREDOMINATING

Breakfast: Cereal cooked in milk, chicken hash with egg, popovers, butter and milk as a beverage.

Dinner: Dried-bean purée, halibut steak, potatoes scalloped in milk, tomatoes stuffed with chopped beef, bread and butter, and frozen custard with nut cookies.

Lunch or supper: Baked beans, nut bread and butter, old-fashioned rice pudding, and a glass of milk.

The following shows a day's menus (not at all unusual or peculiar) in which fat foods predominate.

MENUS WITH FAT PREDOMINATING

Breakfast: Oatmeal with cream, sausage, and corn bread and butter.

Dinner: Cream of tomato soup, mutton chop with creamed potatoes, greens cooked with bacon or pork, bread, and suet pudding with hard sauce.

Lunch or supper: Creamed salmon, lettuce with oil dressing, tea biscuits and butter, pumpkin pie, and a cup of chocolate.

The following is an example of three meals of combinations common enough but in which carbohydrate (starch and sugar) predominates.

MENUS WITH CARBOHYDRATE PREDOMINATING

Breakfast: An orange followed by corn cakes with maple syrup, and bread or toast and butter.

Dinner: Meat pie and baked potato, green peas, bread and butter, and cottage pudding with chocolate sauce.

Lunch or supper: Rice croquettes with jelly, rye bread and butter, baked apples, and sugar cookies.

The food and fuel values of the menus served are given below, the portions served being of the average and usual size for an adult.

THE COMPOSITION OF THE NUTRIENTS AND THE ENERGY SUPPLIED BY THE MENUS USED FOR ILLUSTRATION

	Weight of Edible Food Served, Grams	Protein, Grams	Fat Grams	Carbohydrates, Grams	Fuel Value, Calories
Protein meals:					
Breakfast	471	36	50	54	810
Dinner	772	58	64	120	1,288
Lunch or supper	639	33	38	105	894
Total	1,882	127	152	279	2,992
Fatty meals:					
Breakfast	353	24	69	58	949
Dinner	617	33	88	108	1,356
Lunch or supper	621	29	83	98	1,259
Total	1,591	86	240	264	3,564
Carbohydrate meals:					
Breakfast	509	15	32	168	1,020
Dinner	529	40	33	133	989
Lunch or supper	376	14	27	127	807
Total	1,414	69	92	428	2,816

Described in technical terms, for the benefit of the dietitian, the first day's menu supplies 4.2 grams of protein per 100 calories of energy, or 2,356 calories of energy per 100 grams of protein; the meals of the fatty menu, 2.4 grams of protein per 100 calories of energy, or 4,120 calories of energy per 100 grams of protein; and the meals of the starchy (carbohydrate) menu, 2.5 grams of protein per 100 calories of energy, or 4,081 calories of energy per 100 grams of protein.

Speaking in terms of the housekeeper; Into the first day's menu there went sixteen food materials other than fresh fruits and vegetables, of which nine were from Group 1. Milk entered into or made up ten dishes; eggs, four; nuts, two; and beef, fish, chicken, dried beans, and dried peas, each, one. Into the second day's menu went nineteen food

materials other than fresh fruits and vegetables, of which nine were distinctly fatty foods (lard, oil, butter, cream, salt pork, and others), while the meat, fish, and even the cereal chosen were those which contained comparatively high percentages of fat. Into the third day's ration went eleven food materials, of which six were starchy or sugary (rye, wheat, corn, rice, maple syrup, cane sugar).

Thus, by unwise choice one characteristic of the well-chosen diet—a right proportion between protein and fuel—was omitted.

It is hardly necessary to say that different combinations of vegetables and fruits may be made in which the proportion of mild vegetable acids and ash to the other nutrients in the total diet may vary widely—a fact which could be shown by similar groupings of food materials into menus.

To benefit by well-selected menus, each member of the family should eat all of the kinds of food provided, for, if a person habitually eliminates some particular sort of food as fruits and green vegetables, he has failed to take advantage of the housekeeper's selection, no matter how good it may be. One must, speaking broadly, relish all kinds of food, which is a matter of good habits and good manners as well as of physiological importance.

The housekeeper who will learn the simple classification of foods mentioned above can easily see the relation of the different groups of foods to the character of the meals she provides. She need only go a step further to realize that it is wiser to provide dishes varied in character for a given meal, and also meals varying from those of the same day and varying from day to day. She can do this easily by taking care to see that the different food groups are represented in at least two of the three meals she serves each day. The more extended her information as to market facilities, the wider her knowledge of standards of quality, the wiser her selection of foods, and the greater her skill in preparing and cooking them, the easier it will be for her to plan meals by this or any other method, which will be reasonable, economical and satisfactory, as well as adequate.

She can understand also that it is more important to apply the principle outlined to a considerable period of time than to a single day. A departure from the ideal for a day or so means little, for it can be made up the next day or the next week, while an irrational diet, if followed for a long period, may lead to marked disturbance or even serious illness.

The housekeeper need not go into the reasons for all these things which she has to attend to, but she will be quick to see in a general way the point of it all in so far as it concerns her problem of preparing suitable meals for her family. She need not know the theories of electricity to use and appreciate an electric light, nor need she be burdened with the theories of dietetics, if she is willing to trust the conclusions others have reached and apply them to her particular problems.

She naturally wishes for some tangible proof that her efforts to provide a rational diet as part of her good housekeeping are meeting with success. The general condition of her family should offer her fairly good evidence. Thus, it seems fair to say that the child who continues to approximate the average for his years with respect to weight and height, who is apparently normal in respect to work and play, and who exhibits none of the obvious symptoms of ill health can not be very faultily fed, any more than can be the adult who remains in fairly constant weight for long periods of time, making due allowance for the seasonal variations (such as the small loss in weight in summer and the small gain in winter), and has other attributes of good health. As one reaches middle life it is wise to be more abstemious in matters of diet, as in other things, for the body is "slowing down" and becoming less active and so needs less food. If, in any case, things do not seem to be as they should be, advice should be sought from a physician or other expert, as he alone can judge whether there is an actual departure from normal and whether it is due to diet or to some other cause.

Experience shows clearly that the experimental and the professional worker can be more helpful to the housekeeper than heretofore. The Department of Agriculture is doing what it can to accomplish this important end. The method for translating technical matters of diet into housekeepers' terms, which is outlined above, is an attempt to do this. The method can be modified as experience indicates is desirable, and the subject-matter can be amended to keep pace with the results of investigation and experiment.

What we can now do to help the housekeeper solve her problems falls short of the ideal, but, at any rate, what has been accomplished would seem sufficient to show her that her problems are recognized as worthy of study, and that an extended and consistent effort is being made to give them the attention they merit. In this movement the United States Department of Agriculture is taking part to the full extent of its opportunities.

THE PROGRESS OF SCIENCE

THE RESOURCES AND THE INVENTIONS OF THE UNITED STATES

THE annual report of the Secretary of the Interior reads less like an official government document than like a sermon or a panegyric. This is obvious from the headings of the sections, which are: National pride in development; The foundations of power; The era of splendid giving; To use, not to hold or waste; Taming the rivers for use; Places of beauty as an asset; Young America; The test of a democracy; Administrative effort. Mr. Lane, indeed, begins by defending his own method, telling us that those foreigners who write of our country often engage in facetious if not scornful comment upon our bombastic manner of telling the story of our growth and of the things achieved or possessed. But he says they fail to see far enough into the secret of our pride. "We have a passion for

THE UNITED STATES

Invention	Inventor	Date
Telephone	Bell	1876
Typewriter	Sholes	1878
Cash register	Patterson	1885
Incandescent lamp	Edison	1880
Talking machine	..do	1878
Electric furnace reduction	Cowles	1885
Electrolytic alkali production	Castner	1890
Transparent photograph film	Eastman	1888
Motion-picture machine	Edison	1893
Buttonhole sewing machine	Reece	1881
Carborundum	Acheson	1891
Calcium carbide	Willson	1888
Artificial graphite	Acheson	1896
Split-phase induction motor	Tesla	1887
Air brake	Westinghouse	1869
Electric welding	Thomson	1889
Type-bar casting	Mergenthaler	1885
Chain-stitch shoesewing machine	French & Myers	1881
Single-type composing machine	Lanston	1887
Continuous-process match machine	Beecher	1888
Chrome tanning	Schuls	1884
Disk plows (modern type)	Hardy	1896
Welt machine	Goodyear	1871
Electric lamp	Brush	1879
Recording adding machine	Burroughs	1888
Celluloid	Hyatt	1870
Automatic knot-tying harvester machine	Appleby	1880
Water gas	Lowe	1875
Machine for making barbed wire	Glidden	1875
Rotary converter	Bradley	1887
Automatic car coupler	Janney	1873
High-speed steel	Taylor & White	1901
Dry-air process for blast furnace	Gayley	1894
Block signals for railways	Robinson	1872
Trolley car	Van Depoele & Sprague	1884–1887
Harveyized armor plate	Harvey	1891

FOREIGN

Invention	Date	Inventor	Nationality
Electric steel	1900	Heroult	French.
Dynamite	1867	Nobel	Swedish.
Artificial alizarene (dye)	1869	Graebe & Lieberman	German.
Siphon recorder	1874	Thompson	English.
Gas engine, Otto cycle	1877	Otto	German.
Wireless telegraphy	1900	Marconi	Italian.
Smokeless powder	1886	Vielle	French.
Diesel oil motor	1900	Diesel	German.
Centrifugal creamer	1880	De Laval	Swedish.
Manganese steel	1884	Hadfield	English.
Electric transformer	1883	Gaulard & Gibbs	Do.
Cyanide process for extracting metal	1888	Arthur & De Forrest	Do.
Mantle burner	1890	Welsbach	Austrian.
By-product coke oven	1893	Hoffman	Do.

going into the unknown, for answering the puzzles that are put to us. Our imagination is challenged by difficulty. And the result has been a century of growth, which in its magic and in its largeness casts a spell upon the mind."

The story that Mr. Lane tells is indeed marvelous. We produce 66 per cent. of the world's petroleum, 60 per cent. of its copper, 40 per cent. of its coal and iron. Within fifty years we gave in subsidies to railroads public lands that exceeded in size a territory seven times as large as the state of Pennsylvania. We have given to the states, for the sustaining of their schools and other public institutions, an amount that our records do not accurately state, but thirteen western states were given over 67,000,000 acres. We have water power that can be made to generate perhaps as much as 60,000,000 horsepower. The waters that flow idly to the sea could be made to support not less than 50,000,000 people if turned upon the land.

Perhaps in some cases Mr. Lane overexalts our achievements. For example, he tells us that the public-school system is the most successful social enterprise yet undertaken by any people, that on it we spend three-quarters of a billion dollars a year. "Education is indeed our foremost industry, from whatever point of view it may be regarded." But we should need to double the amount spent in education to make it financially comparable with the advertising business, to quadruple it to rival the liquor trade.

Mr. Lane writes: "During the past fifty years the people of the United States have uttered two thirds of all the revolutionary epoch-making inventions of the world, ranging from the telephone and the incandescent lamp to Wright's aeroplane and high speed steel." In this case the evidence is supplied by the forty-three examining divisions of the patent office. It will not be convincing to foreign critics or to all Americans but is of sufficient interest to be reproduced.

RUINS OF THE MESA VERDE NATIONAL PARK

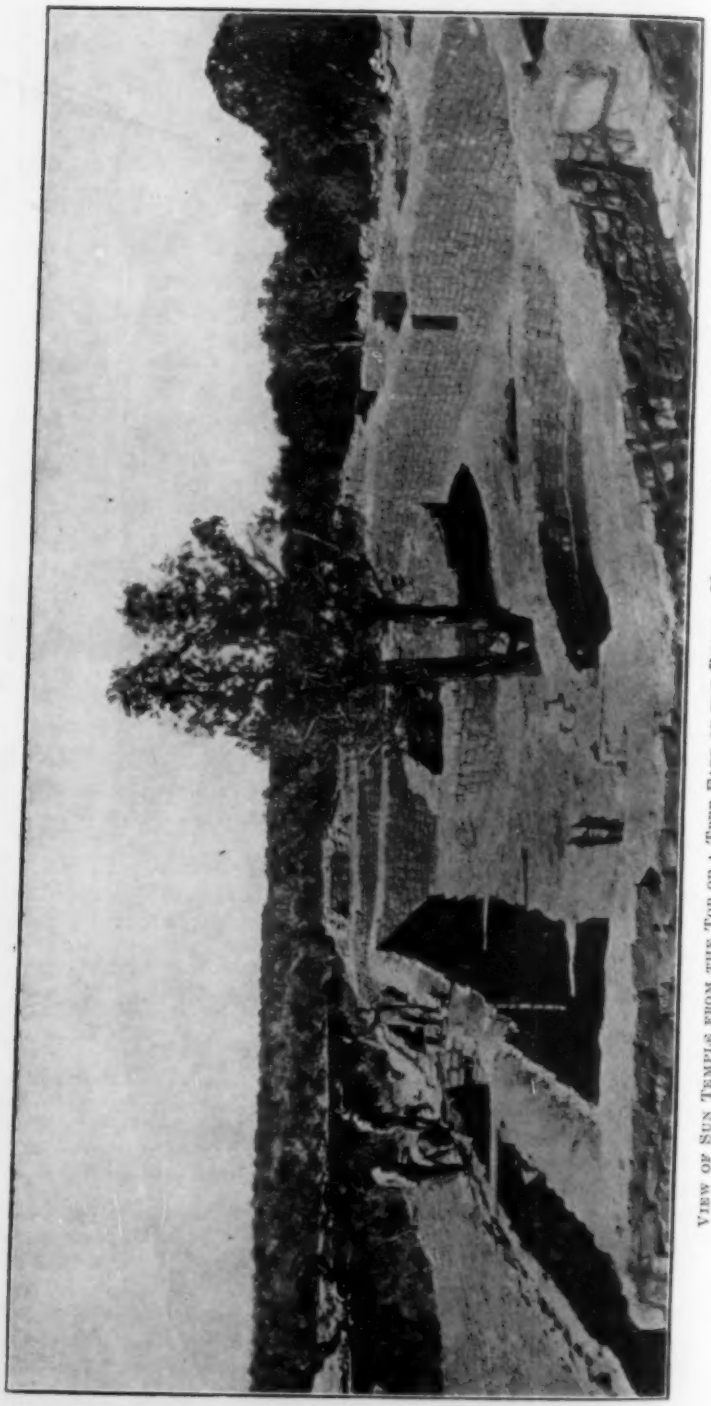
THE large tract of land in southwestern Colorado, now known as the Mesa Verde National Park, was set aside from the Ute Reservation by an Act of Congress in 1906 on account of the numerous ruins of cliff dwellings which occur in its canyons. This enlightened legislation was in response to the universal recognition that these remains had an educational importance. It was largely brought about by the efforts of women of Colorado, members of a local state organization known as the Colorado Cliff Dwellers Association. At about this time or a few years before there was a general awakening of

VIEW OF SUN TEMPLE FROM INSPECTION POINT, ACROSS THE CANYON. Also the Cliff Palace in the cave to the right.

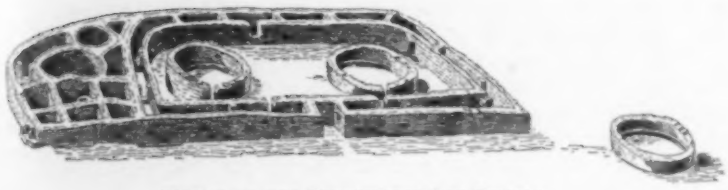
interest in prehistoric monuments throughout the country, when it was recognized that unless laws for the protection of the ruins of the Southwest were made, in a few years these survivals of the past would practically be destroyed by collectors whose efforts were mainly stimulated by the commercial value of pottery and other small objects they contained. The sequestration of the Mesa Verde National Park was accompanied by an appropriation of money for its development: payment of salary of a superintendent, building roads and current expenses. The administration of the park was naturally placed in the hands of the custodian of public lands, the Secretary of the Interior. This official wisely set aside a part of the appropriation for clearing the fallen débris from the rooms, and making such repairs as were needed for preservation of the walls. As this kind of work is of a scientific character, the Secretary of the Smithsonian Institution was called upon to designate an archeological expert to take immediate charge of the work.

The policy adopted by the Secretary of the Interior has been continued from year to year with satisfactory results. Three of the largest and most typical cliff dwellings of the park have been excavated and repaired; roads have been constructed to them, so that now the student or tourist can visit, by automobile from Mancos, on the Denver and Rio Grande Railroad, without discomfort, the well-known cliff dwellings called Spruce-tree House, Cliff Palace and Balcony House.

Up to last summer the Mesa Verde National Park was widely known from its cliff dwellings, but archeologists were cognizant of mounds indicating villages situated on the mesa top. Although the walls of buildings were not visible projecting above the surface it



VIEW OF SUN TEMPLE FROM THE TOP OF A TREE EAST OF THE RUINS. Men cementing on the top of the east wall.



SKETCH OF THE PREHISTORIC SUN TEMPLE.

was believed that there were buildings of a different type of architecture hidden below these mounds, and it was recognized that it would be well to open up one of these mounds and examine its contents, in order to enlarge our knowledge of the culture of the prehistoric inhabitants of this region.

One of these mounds is situated on a commanding promontory across Cliff Canyon, opposite Cliff Palace, or between the former and a side branch following the same general direction. The stones artificially worked that covered the surface of this mound gave indications of important results, but the extent of the mound was hidden from view by a growth of cedar and other trees. A shallow excavation had been made at one point by "pot hunters," which revealed a section of wall and confirmed the belief that rooms were buried below the mound, but the fragment thus brought to light gave no indication of the extent, shape or purpose of the building to which they belonged.

The scientific field work on the park, in 1915, was entrusted to Dr. J. Walter Fewkes, ethnologist in the Bureau of American Ethnology, of the Smithsonian Institution, who had in previous years excavated and repaired Spruce-tree House and Cliff Palace. The plan of work was a complete excavation of the mound, repair and study of the building, if any within it, and an investigation of its character and purposes. A report of this work has just been made to the Secretary of the Interior in which a popular exposition of the discoveries is treated. The statements made in this report indicate that this building belongs to an architectural type hitherto unknown in the Mesa Verde National Park, and differs from any formerly described. Its ground plan is well compared to a letter D, the straight side or south wall overlooking the point of a promontory measuring 121.7 feet from east to west; the curved portion being approximately 340 feet, while the breadth is about 64 feet. A marked feature in form which strikes one at first sight is the remarkable unity in its construction, the fine masonry of the walls and their massive character. Although apparently constructed in two sections at different times, it is evident that this huge, mysterious structure is a unit and followed a plan that was thought out before the foundations were laid, the massive walls being completed without essential modification. The building was not made up of rooms patched one on the other, from time to time, as is generally the case with cliff dwelling architecture.

A PREHISTORIC SUN TEMPLE

In his official report the author after considering various details takes up three of the many questions ordinarily asked by visitors, viz.: What is the age of the building, the kinship of the builders and the purpose of its construction. There is no doubt that it was prehistoric, for a large cedar tree with 360 annual rings was found growing on the highest point of the mound, on top of the walls before excavation began. This tree sprouted as far back as 1540, or the time the discoverer of the Southwest, Coronado, first entered what is now southern New Mexico. The number of stones filling the rooms covered

by the débris indicates that the walls were formerly considerably higher and had fallen before the tree began to grow. If restored to their former place they would raise the wall six feet. The construction of this wall implies a time still further back. While the exact age can not be determined, the mound of débris would imply at least two centuries between laying the foundations and the sprouting of the cedar tree.

The purpose of the building is, and will remain, a mystery, but by elimination of theories which can not be accepted, the author believes it was a building devoted to ceremonials, or a temple. Unfortunately for all theories of use, the indications are that the walls were never finished. The rooms are not suitable for living rooms and the building shows no signs that it was intended for habitation. There are no indications of piles of débris, nor were utilitarian objects, like pottery, found in the rooms; no marks of smoke or plastering appear on the wall. It was never roofed. The theory that it was used solely for a fortification is equally unsatisfactory: there are no portholes, or places where its defenders might stand; no reservoir to supply water to warriors. Like the theory of defense, the suggestion that it was used for storage of food is likewise indefensible. Although protection and storage may have been secondary purposes, the shape of the rooms and their character implies that it was not primarily constructed for these ends. Not being able to accept any other theory, there remains but one other which strongly appeals to the author, which is that this large building was constructed for ceremonial uses. In support of this theory are mentioned certain large rooms, identified as kivas, which we know the cliff dwellers devoted to ceremonial rites. Similar rooms used for the same purpose survive in pueblos of the present day. Other reasons are advanced supporting the belief that this building was intended for a temple. The key to the whole structure, following this interpretation, is a shrine built on the corner-stone, under the southwest corner of the ruin. The symbolic figure on the floor of this shrine is a fossil palm leaf, identified as a representation of the sun, and suggesting the name, Sun Temple.

The question, Who built Sun Temple? is not less difficult to answer satisfactorily than those of its age and purpose. It has significant resemblance in architectural form to one of the great pueblo ruins in the Chaco Canyon, and the circular room of the annex with its surrounding chambers suggests the double walled "towers" found in the McElmo Canyon, and along the lower course of the Mancos River. There are deep-seated resemblances in the architectural and ceramic characters of these regions referred to which indicate that they belong to the same culture area, and it is possible that the center of diffusion of this culture was the Mesa Verde region. Although Sun Temple belongs to a type different from any of the well-known cliff dwellings of the Mesa Verde National Park, it shows evidences that it was not built by people from a distance but by inhabitants of the cliff houses of the Mesa Verde.

SCIENTIFIC ITEMS

We record with regret the death of Dr. C. Willard Hayes, formerly chief geologist of the U. S. Geological Survey; of Dr. John Orren Reed, professor of physics at the University of Michigan; of Dr. Oswald Külpe, professor of philosophy and psychology at Munich; of Dr. Richard Dedekind, professor of mathematics at Brunswick, and of Mr. A. D. Darbishire, lecturer on genetics in the University of Edinburgh.

The Bruce gold medal of the Astronomical Society of the Pacific has been awarded to Dr. George Ellery Hale, director of the Mount Wilson Solar Observatory.